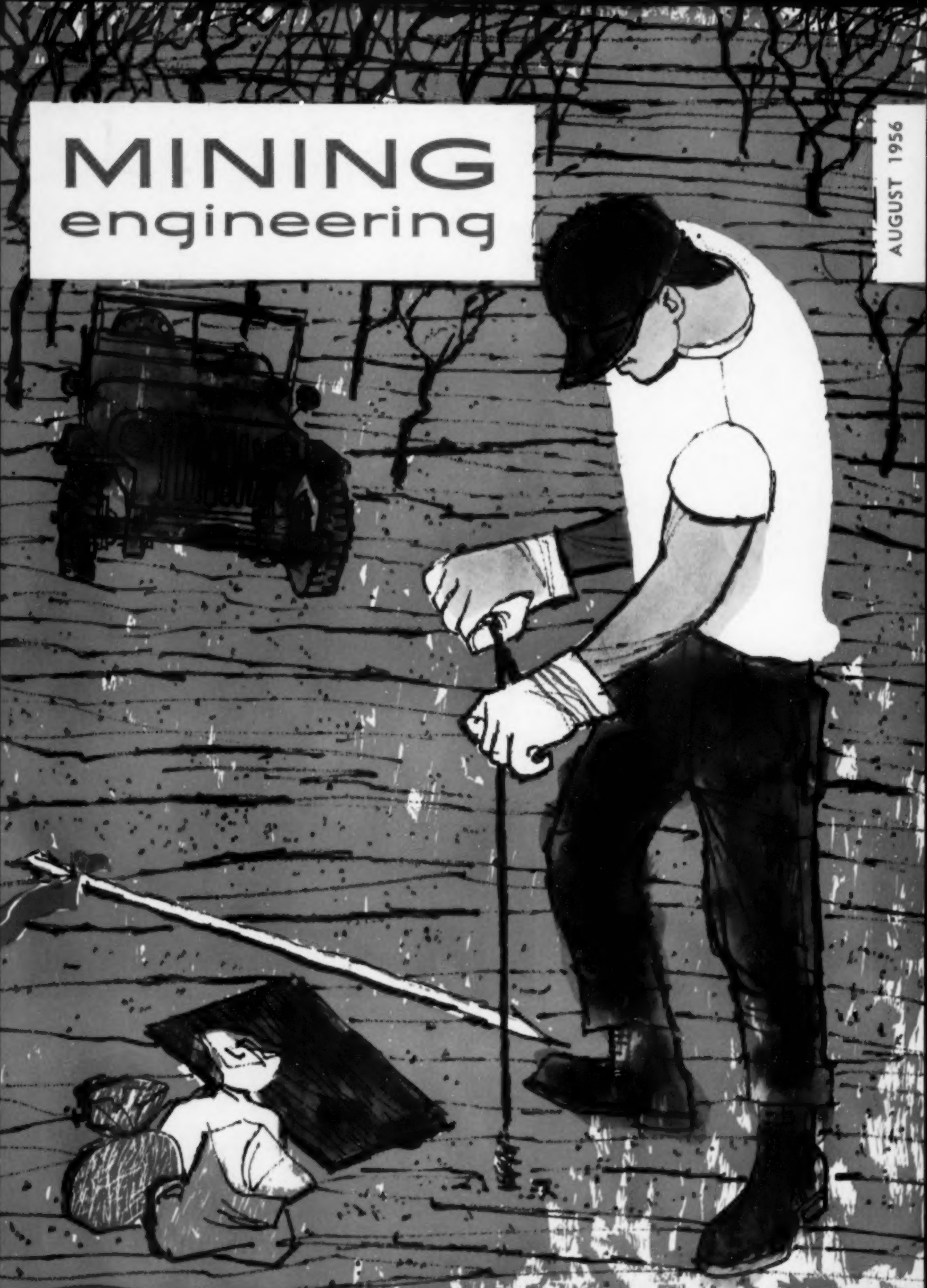
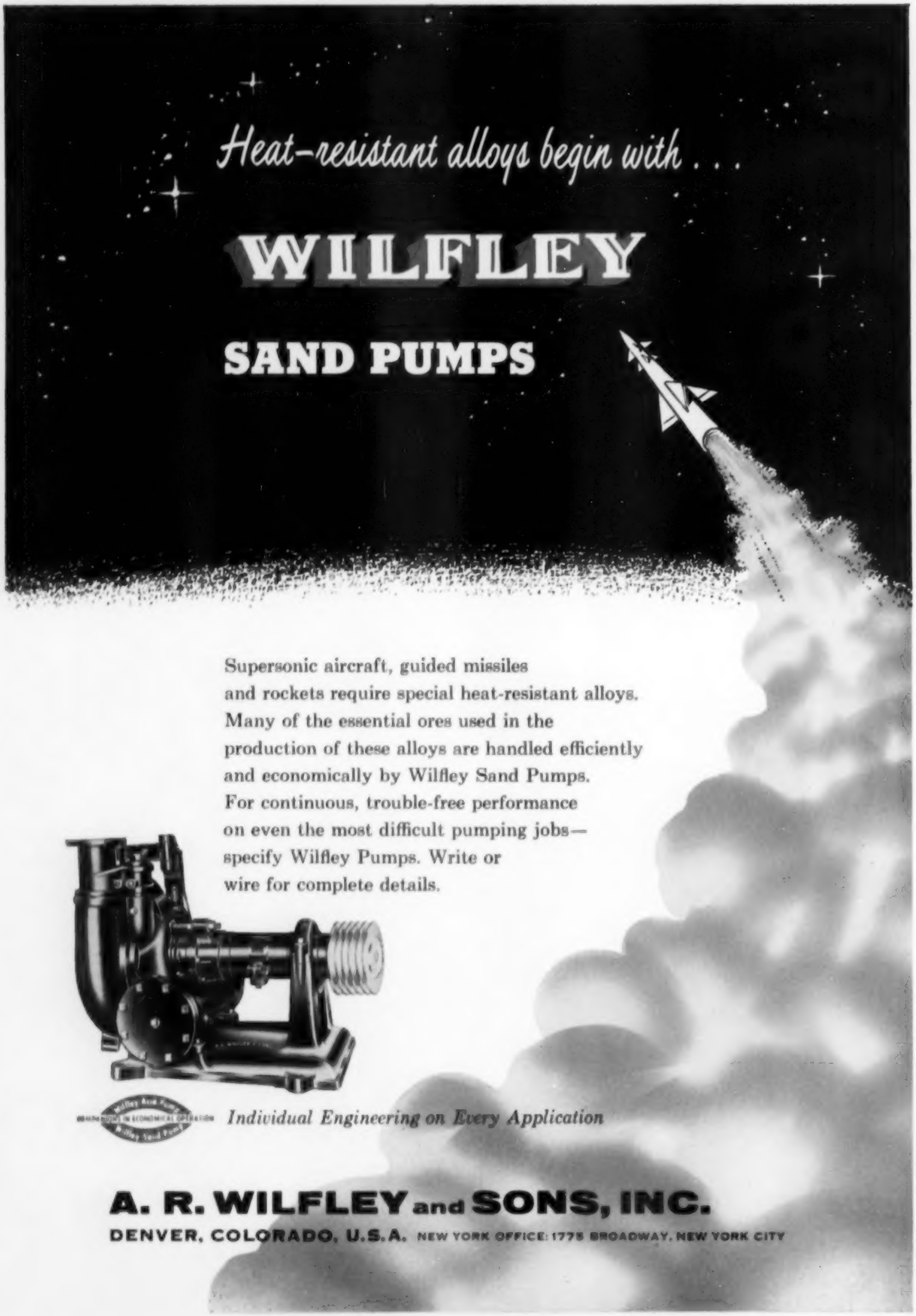
MINING engineering

AUGUST 1956





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MINING BRANCH AIME

MINING engineering

VOL. 8 NO. 8 AUGUST 1956

COVER

Soil sampling, topic of this month's cover by Artist Herb McClure, is one of the intriguing exploration techniques reviewed by W. E. Heinrichs, Jr., in his review of the present-day status of geochemical prospecting. For the full story, turn to page 809.

FEATURES

ARTICLES

TRANSACTIONS

PERSONNEL

THE following employment items are made available to AIME members on a non-profit basis by the Engineering Societies Personnel Service, Inc. (Agency) operating in cooperation with the Four Founder Societies. Local offices of the Personnel Service are at 8 W. 40th St., **New York 18;** 100 Farnsworth Ave., **Detroit;** 57 Post St., **San Francisco;** 84 E. Randolph St., **Chicago 1.** Applicants should address all mail to the proper key numbers in care of the New York office and include 6c in stamps for forwarding and returning application. The applicant agrees, if placed in a position by means of the Service, to pay the placement fee listed by the Service. AIME members may secure a weekly bulletin of positions available for $3.50 a quarter, $12 a year.

——MEN AVAILABLE——

Mining Engineer, 44. Three years as factory representative for mining equipment company in the Orient and India. Experienced export trade. Seventeen years as mine manager, superintendent, foreman, shiftboss, engineer, and miner in medium and small copper, Pb-Zn mines. Desire connection with a progressive mining company or in export department of export firm. M-279-San Francisco.

Mining Engineer, 37, graduate, Canadian, available early August. Eight years varied experience mine engineering and heavy media plant supervision. M-275.

Graduate Mining Engineer (Mining Academy, Austria), mechanical engineer, technical school, 30, single. Eight years varied experience underground mining, coal, and hard rock; draftsman, production, and planning engineer. Seeks responsible position mining company, foreign country, preferably Africa. Presently located in Africa. M-276.

Exploration Mining Engineer, 49, B.S. Six years office engineering exploration evaluation. Eight years domestic and foreign field examinations. Four years mineral economic studies. Nine years diversified metal mining experience. Currently employed, desires responsible position in exploration, preferably nonmetallics. Will go anywhere. M-278.

MINING ENGINEER, B.S., 32, family. Six years engineering experience in underground hardrock mining. Seeks opportunity for responsibility in engineering, operations or sales. Good record. Available on reasonable notice.

Box 8-H AIME
29 West 39th St. New York 18

GRADUATE MINING ENGINEER—nine years' previous experience metal mines. Single, 29, seeks position in a mine tropical and sub-tropical countries preferred. Apply to:

Box 7-H AIME
29 West 39th St. New York 18

——POSITIONS OPEN——

Administrative Assistant, degree in mining engineering or geology, 27 to 32, with three to five years field experience in mining or geology. Will review monthly progress reports from subsidiary companies to summarize them for management; review reports on outside properties to determine their potential as mining ventures, including necessary financial calculations; prepare ore and metal studies as to operating costs; generally assist technical managers on legal, governmental, and similar matters. Salary, $6000 to $8400 a year. Location, New York. W3655.

Mining Engineers. (a) Junior Engineer, with one or two years experience in mine surveying. (b) Mine Safety Engineer, at least 35, with varied experience in mine and mill safety work. Salaries open. Location, northern New Jersey. W3619.

Mining Engineers. (a) General Manager, mining engineering graduate, with at least ten years experience in general charge of bituminous mining operations and coal preparation. Salary open. Location, Pennsylvania. (b) Mine Superintendent, mining engineering graduate, with at least five years supervisory production experience in underground metal mine. Salary open. Location, Canada. W3616.

Mining Engineer, young, to do well-site work during summer and mine-design work in winter for large potash exploration in northern Canada. Salary open. W3447.

Mining Engineer, with five to ten years experience, to do exploration, evaluation, mapping, and development for metal mining company. Salary, $7800 a year. Location, Tennessee. W3420.

Project Manager, 35 to 45, graduate mining engineer or engineering geologist, with 10 to 15 years exploration experience, preferably foreign. Both supervisory and field experience desirable. Will plan, organize, and supervise all exploration activities in connection with a major exploration effort. Should write and speak Spanish. Salary, $13,000 annually plus 33 1/3 differential plus 100 pct expenses while away from base city. Location, South America. F3570(a).

Engineers. (a) Assistant Mine Superintendent, graduate mining engineer, with extensive background and experience, to assume duties of assistant mine superintendent at well established camp at altitude. Excellent opportunity for advancement. Salary, $7800 a year in U. S. currency. Location, South America. (b) Assistant Mill Superintendent, qualified to assume position of mill superintendent; will be assisted by general mill foreman. Mill treats 720 tpd of Au-Cu ore by straight cyanidization. Close metallurgical control required. Single man will be provided with room and board at company expense; married man will be furnished a house, basically furnished, rent free, and granted a living allowance of $75 per month. Salary, $6000 a year, U. S. currency. Location, Central America. F3551.

Recent Graduate Engineers, mining, for mining properties in South America. Salaries, from $6000 a year. Company will pay placement fee. Transportation and living quarters provided. Single status. Location, South America. F3407.

WANTED: Chief Geologist to supervise geological work of mine development program and head up general exploration in Chile. 8 to 10 years' experience in mine and exploration geology required, some of it in Latin America. Knowledge of Spanish essential. Contract. Salary open. Reply giving full particulars to Employment Manager, Cerro de Pasco Corporation, 300 Park Avenue, New York 22, N. Y.

MINING ENGINEER OR GEOLOGIST

Opportunity in New York office of international nonferrous metal corporation for man with background and knowledge of mining and exploration. Minimum 3 years' experience. Send full particulars including experience, education, age and salary desired to:

Box H10-M AIME
29 West 39th Street
New York 18

Chemical, Mechanical or Mining Engineer with experience in cement plant operation or manufacturing process research. Pleasant location near Chicago. Interesting work, some travel. Reply to:

Box 9-H AIME
29 West 39th St. New York 18

METALLURGIST wanted by Northwest phosphate company to take over operation of beneficiation pilot plant and carry through this work to full-scale plant operation. Salary open.

Box 12-H AIME
29 West 39 St. New York 18

Eimco 630 Tractor-Excavator is air powered for tunnel operation.

EIMCO 630 EXCAVATORS SPEED DEVELOPMENT

High speed development can be maintained underground with only the normal shift crew. The Eimco 630 helps the miner or contractor realize this goal because it operates faster and requires no track.

The Eimco 630 Excavator is mounted on the Eimco 630 air or electric (A.C.) powered tractor and the combination unit provides the operator with a really mobile and versatile loading machine.

With its independently controlled tracks the Eimco 630 Excavator can dig in at the toe of the muck pile, bulldoze out into stations cut along the side, walk over, around and through unworkable areas in the mine eliminating the necessity for laying rails.

It is also in use for shaft sinking in round and rectangular shafts. It is being used on slopes and for mucking out sub-level ore pockets.

In all of the applications where the 630 has been employed the costs of handling the material have been less than with previously used equipment.

The Eimco 630 is rugged, requires a minimum of maintenance attention and has the same dependability that has been characteristic in Eimco made equipment for more than half a century.

Write for complete information.

BOOKS

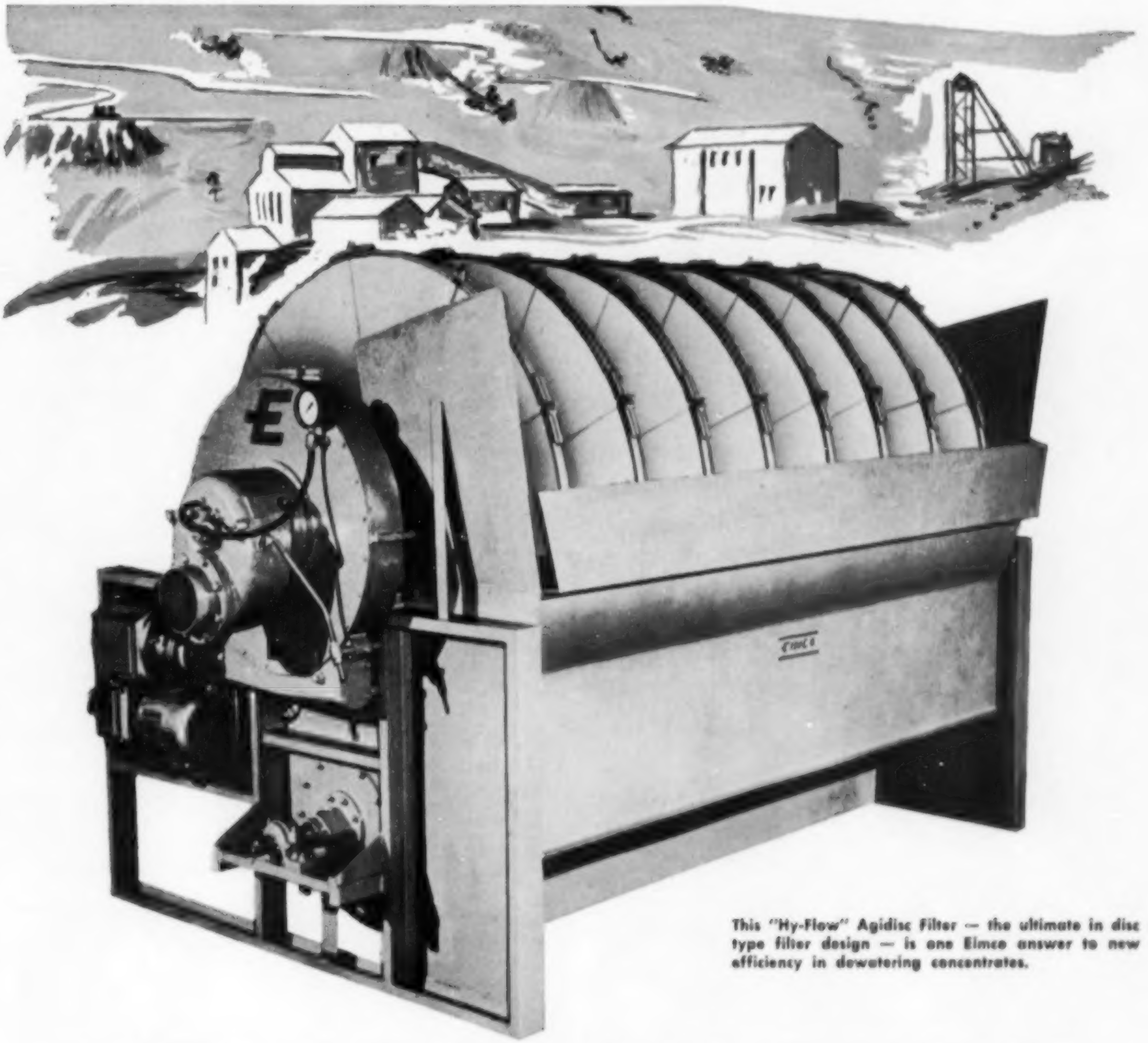
ORDER THE FOLLOWING BOOKS THROUGH AIME— Address Irene K. Sharp, Book Dept. Ten percent discount given whenever possible.

Mining Year Book 1956, compiled by Walter E. Skinner, *Walter E. Skinner*, London, $7.00 postfree, 883 pp., 1956.—Complete and up-to-date information on 951 mining companies operating in all parts of the world. Particulars include directors, dates of incorporation, description of property, plant erected or in course of erection, capital, dividends, and financial position. Addresses are given for 1202 mining engineers and managers and the companies with which they are connected.

Modern Chemical Processes, Vol. 4, by the editors of **Industrial and Engineering Chemistry**, *Reinhold Publishing Corp.*, $5.00, 202 pp., 1956.—This inventory of American chemical technology is a reference book for the practicing industrial chemist, the chemical engineer and the advanced student in these fields. Nineteen recently developed chemical processes, now in operation are described as to background, details of plant installation, process and operation of plants, economics of process, personnel and future prospects, including technological improvement of the process.

India's Mineral Wealth, by J. C. Brown and A.K. Dey, *Oxford University Press*, 3rd edition, 761 pp., $7.95, 1955.—Each of the useful minerals found in India is considered individually as to occurrence, history of commercial exploitation, and uses in modern industry. Four parts of the book are devoted to the various classes of minerals: fuels, metals and their ores; industrial minerals and rocks; and precious and semiprecious stones. A fifth part consists of discussion of water and soils. Geologic maps and a list of selected references are included.

The College Blue Book, edited and published by *Christian E. Burckel*, N. Y., $12.00, 688 pp., 1956.—A standard work of reference of higher education in the U. S., this eighth edition replaces the 1953 edition. The volume supplies information about every institution of higher learning requiring graduation from a secondary school for admission and includes a section on engineering schools by W. Leighton Collins, Secretary ASEE, and lists the engineering curricular accredited by ECPD. Other sections of particular interest to engineers are devoted to technical institutions and to scholarships, foundations and research.



This "Hy-Flow" Agidisc Filter — the ultimate in disc type filter design — is one Eimco answer to new efficiency in dewatering concentrates.

EIMCO "HY-FLOW" AGIDISC NEW DESIGN FOR IMPROVED FILTRATION

Application of the Eimco "Hy-Flow" design to Agidisc filtration is proving to be a practical and money-saving formula for filtering many metallurgical concentrates.

This new design, which enhances operating efficiency in all zones of the filtration cycle, combined with the Agidisc's ability to maintain constant particle suspension, makes the Eimco "Hy-Flow" Agidisc a highly versatile filter.

Enlarged ports, streamlined passages and direct flow allow an unrestricted passage of liquids and gases from the filter media through the valve.

Also eliminated is vacuum loss, since turbulence and right angle resistance bends are no longer present. The "Hy-Flow" Agidisc incorporates newly designed valves, disc sectors, sector bells and trunnion barrels.

Eimco filtration engineers can produce comparison records to show that "Hy-Flow" Agidisc filtration has dewatered tonnage to a lower moisture content at lower cost than any other filter.

If your operation involves dewatering fast settling solids, the Eimco "Hy-Flow" Agidisc Filter could well be your solution to better filtration resulting in more profit.

Send your particulars to the Eimco Filtration Division. Their advice to you will be based on years of research and experience in the field.

THE EIMCO CORPORATION

Salt Lake City, Utah—U.S.A. • Export Offices: Eimco Bldg., 52 South St., New York City

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B-208

QUEBEC HYDRO-ELECTRIC COMMISSION USES EIMCO 105 TRACTOR-EXCAVATORS ON BERSIMIS PROJECT

The Quebec Hydro-Electric Commission supplied contractors on the huge Bersimis project with several Eimco 105 Tractor-Excavators as the most efficient machines available for certain phases of the job.

Eimco 105's worked on the penstocks at the power-house, loaded blasted rock at the diversion tunnel, mucked in the intake shafts, assisted in clean up of the main tunnel, loaded aggregate from the quarries and accomplished numerous other jobs including, (as shown above) the takeup of the bottom in the main tunnel.

The main tunnel bore at Bersimis is 7 miles long and excavated diameter was 45 feet. The intake shaft on the Diversion tunnel was 32 feet in diameter by 120 feet deep. The Bersimis project is scheduled to generate power by July or August of 1956.

Contractors have worked steadily in the face of adverse weather conditions to complete this great work at an early date. Eimco extends its heartiest congratulations on a job well done.

Eimco 105 Tractor-Excavators are at work throughout the world on Hydro-electric development projects, mines, roadbuilding, stockpile loading, pits and quarries and many other rough jobs. In many instances, the 105 is the only production equipment on the job—because its dependability is a well known and proven fact.

If your project calls for a tractor, bulldozer, or excavator, you'll want Eimco to supply you with full information about the versatile 105. Just send details of your project. You'll find, as have many others, that Eimcos will do the job faster, cheaper and better.

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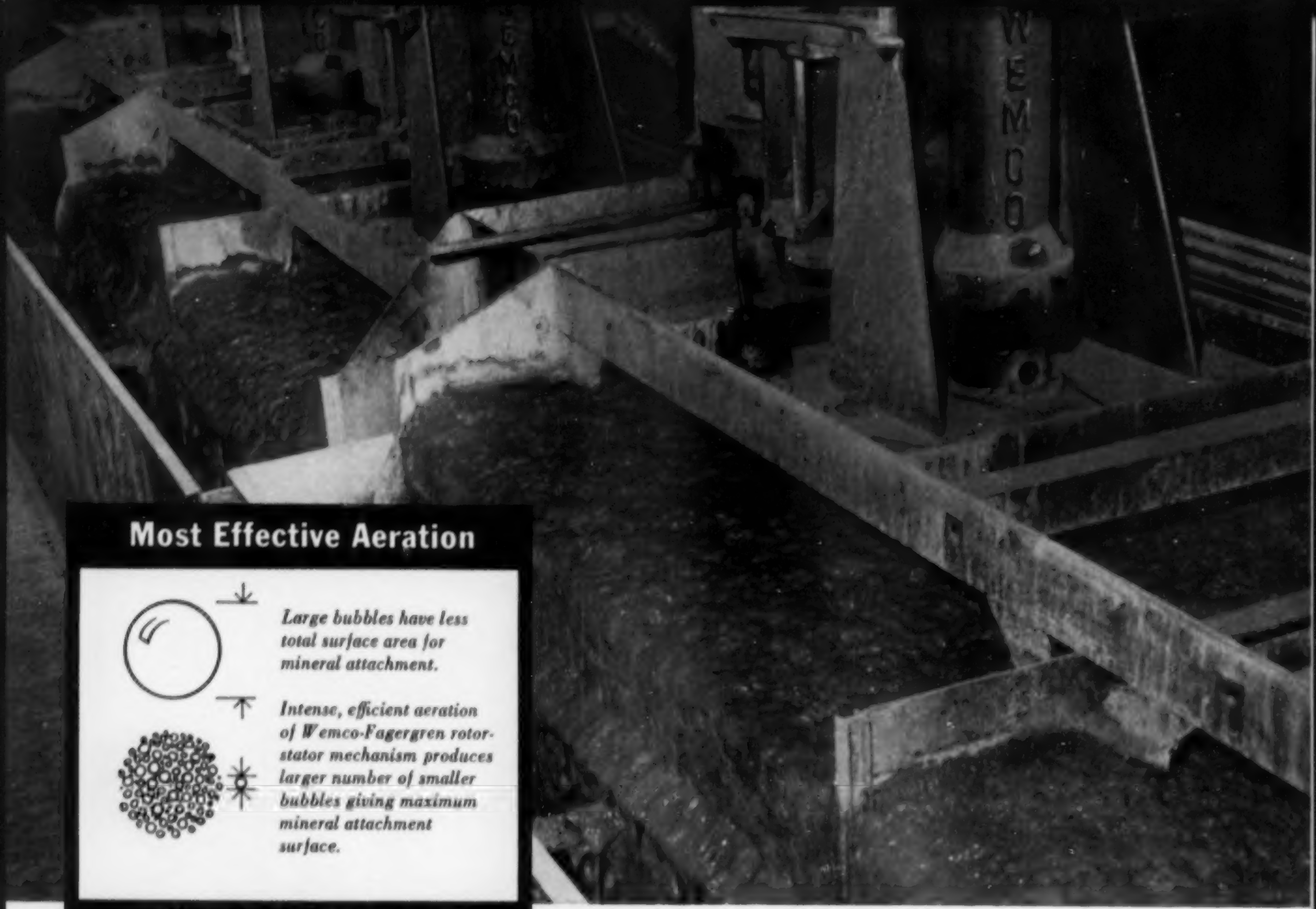
B-815

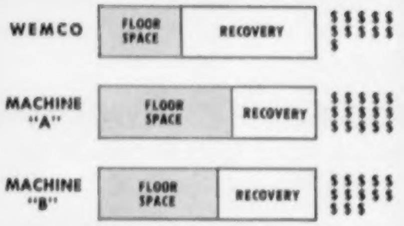


Most Effective Aeration

Large bubbles have less total surface area for mineral attachment.

Intense, efficient aeration of Wemco-Fagergren rotor-stator mechanism produces larger number of smaller bubbles giving maximum mineral attachment surface.

Greatest Recovery per Dollar



Highest Recovery of Values

1.5% more molybdenum
1.0% more copper
5.0% more silver
1-2% more gold
— with Wemco

by every competitive test... Wemco Fagergren proves best

In recent, rigorous testing with top-notch competitive equipment, Wemco Fagergren Flotation Machines proved best in recovery, grade, floor space, cost and maintenance — as the following test results indicate:

"...One goal of the test was *recovery*, without sacrifice in grade, and the *Wemco Fagergrens consistently led in this factor.*

"...as the test progressed there was a trend to increase tonnages of feed per machine. As these tonnages were increased, operating horse-power increased on all machines *except the Wemco Fagergrens.*

"...mechanical and design changes were made on several occasions in (two of the competitive) units. During the testing program *there were no mechanical revisions or design changes on the Wemco Fagergrens.*"

• And as final proof of their superiority, Wemco Fagergrens also excelled on such important counts as *simplicity of operation . . . least total number of mechanisms required . . . longer effective life of wearing parts.*

For more details of Wemco leadership, write today

WEMCO
WESTERN MACHINERY COMPANY

Representatives throughout the United States and Canada and in major countries around the world.

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To celebrate its first birthday

THE D9 GETS INCREASED HP

—more power for your operation!

320 HP
(FLYWHEEL)

formerly 286 HP

260 HP
(DRAWBAR)

formerly 230 HP

The giant Turbocharged CAT* D9 Tractor, which since its introduction last year has set new performance standards in the field, now packs more power than ever to handle even bigger jobs. Its drawbar capacity has been increased from 230 HP to 260 HP—its flywheel horsepower from 286 to 320!

This increase in power reflects Caterpillar's policy of leadership in action. Combining research with practical field experience, there's constant product improvement to meet your needs for bigger production at lower cost. This policy applies to *every* product in the Caterpillar line—Diesel Engines, Tractors, Motor Graders and Earthmoving Equipment.

Now, with its increased horsepower, you can give the D9 tougher jobs than ever before. To match your requirements, it's available with torque converter or direct drive with oil clutch. For complete details about the more powerful D9, see your Caterpillar Dealer. Name the date—he'll be glad to demonstrate!

Caterpillar Tractor Co., Peoria, Illinois, U.S.A.

CATERPILLAR*

*Caterpillar and Cat are Registered Trademarks of Caterpillar Tractor Co.

D9—MORE POWERFUL FOR BIGGER PRODUCTION

Manufacturers News

News
Equipment
Catalogs

• FILL OUT THE CARD FOR MORE INFORMATION •

Automatic Welder

Rexarc RP-43 roll and idler welder and positioner by *Sight Feed Generator Co.* is a packaged unit designed for automatic welding on circular shapes such as idlers, sheaves, crusher rolls. Speed range of 0.13 to 1.33 rpm allows building up of the smallest roll to the largest weldment. Self-locking 120° tilting table for adjustable positioning of the rotating shaft provides versatility. Flux supply is always visible in a flux hopper of 100-lb capacity. **Circle No. 1.**

Vibratory Products

Syntron Co.'s line of vibrators and other industrial equipment is newly illustrated in a 52-page pocket-size catalog. Vibratory screens, feeders, shake-out grids, elevators; gasoline and electric hammer drills; diesel pile hammers; power conversion units and many more industrial products are included in the information-packed condensed data of Catalog 564. **Circle No. 2.**

Short Pulse Blaster

Houston Technical Laboratories announces a short pulse blaster consisting of pulser unit and time break unit mounted in a single case. Detonator is said to give positive firing action within a highly restricted time period. A high current is sustained

for 0.3 milliseconds and then reduced sharply to zero within 0.2 milliseconds, confining application time break inaccuracy to 0.5 milliseconds. Portable blaster weighs 12¾ lb and is encased in hardwood, waterproof glued. **Circle No. 3.**

Drill-Hole Logger

Recommended as a general uranium exploration tool and as a seismograph shot-hole logger, the Model GHL-230 logging system by *Mount Sopris Instrument Co.* is said suitable for in-hole radio-assay applications. System includes a portable

reel, Geiger counter with water-tight probe, and a recorder that provides a record of radiation intensity as a function of depth in the hole being logged. Probe is positioned by means of a boom extended forward from the reel and water pressure testing of 1000 psi insures probe operation in water-filled holes. **Circle No. 4.**

Magnetometer

Geophysical Instrument & Supply Co. is the exclusive U. S. distributor for the Sharpe A-2 Vertical Force Magnetometer. One-man operated instrument will aid in mineral exploration problems such as mapping contacts and faults, locating magnetite and pyrrhotite, and petroleum exploration. Sensitivity is as fine as 10 gammas per scale division. Total weight with tripod is 13 lb. **Circle No. 5.**

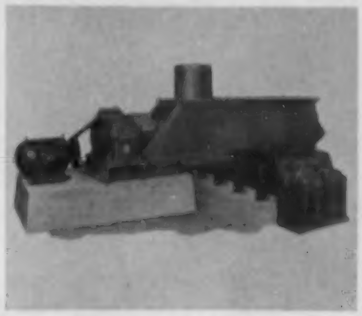
Payhaulers

Two new off-highway rear-dump trucks, the 18 and 24-ton Payhaulers, have been introduced by *International Harvester Co.* Model 65 has a 250 hp diesel engine with a speed range to 36.5 mph and carries 12

cu yd struck. Capacity of the model 95 (above) is 16 cu yd struck and its 335-hp diesel gives speeds to 38 mph. Both trucks feature wide visibility, power steering, welded steel frames, air assist clutches, heavy-duty hydraulic hoists. **Circle No. 6.**

Screw Feeder

Developed for uniform flow regulation of ore fines, flue dust, and other granular materials, *William M. Bailey Co.'s* Screw Feeder (below) features a screw made in sections for simple replacement. Highly abrasive



materials may require the use of a cast ferromanganese screw that is supplied with a hard facing on the edge and wearing face. Roller type bearings are mounted in split cast iron housings. **Circle No. 7.**

News & Notes

LeRoi Div. of Westinghouse Air Brake Co., celebrating its 40th Anniversary, expects completion of its \$5½ million engineering and research expansion project within five years. . . . *Baldwin-Lima-Hamilton Corp.* announces new distributors for Lima shovels, cranes, draglines, and pull shovels: Ray Long Eqpt. Inc., Columbia, S. C.; Emmett C. Watson Co. Inc., Louisville; Evans Engine & Eqpt. Co., Seattle; Reno Eqpt. Sales Co., Reno, Nev.

(21) WELDING DATA BOOK: "Low heat input" metal-joining process using *Eutectic Welding Alloys Corp.'s* principle of "surface alloying" is detailed in the fifth edition of Eutectic's pocket-size welding data book. Booklet has 170 pages of information on special alloys and fluxes to suit most specialized welding applications. Procedures stress ways to save dismantling, pre and postheating Methods of minimizing or eliminating metallurgical structure changes and tensions of base metal, warping, distortion, and cracking are suggested. A useful selection guide for welders, the booklet contains descriptions of more than 60 Eutectic alloys.

(22) WIRE ROPE FITTINGS: Two new bulletins from *Sauerman Bros. Inc.* give specifications on wire rope fittings and sheaves. Open and double wedge sockets for rope sizes from ⅜ to 2 in. are detailed in form 164 and Durolite sheaves in sizes 6 to 24 in. are listed in form 165.

(23) "LET'S MAKE BASIC STEEL": If you are interested in steel production—acid furnace operation and the basic steel process are compared in this 12-page illustrated booklet from *Basic Inc.* A technical reprint, the booklet outlines advantages of basic operation, estimates costs of conversion, and discusses operating problems and solutions.

(24) CONVEYOR BELT IDLER: The Joy Limberoller is a 2-bearing, single-roll, cable suspension idler for belt conveyors. Details on design and application data to be used with belt widths of 18 in. to 72 in. are given in a new 12-page booklet from *Joy Mfg. Co.* Limberoller consists of neoprene or rubber discs molded to a flexible wire rope which is bearing-fitted to a tubular upright bracket. Result is lightweight idler that is self-cleaning, uses fewer bearings, can be spaced further apart, needs no lubrication, and can be changed without stopping belt.

Free Literature

(25) CALCITE FLOTATION: The *Denver Eqpt. Co.* has a flowsheet study that describes the beneficiation of Calcite by Denver "Sub-A" flotation. The method shown in bulletin M7-F48 is one used in beneficiating low grade lime ores for use in cement. Information is included on flotation reagents and thickening and storage.

(26) STEREOSCOPE: Convenient single prism stereoscope by *Booklime Inc.* is intended to aid in interpretation when stereoscopic aerial photos are used. Geologists may find it useful in making surveys, detailed geologic mapping, field checking of topographic maps. Stereoscope is made of heavy aluminum but weighs less than 2 lb. When folded flat it is easily carried in a canvas case that is provided with stereoscope at a combination price of $49.50.

(27) WIRE ROPE SLINGS: ACCO Registered Cable-Laid wire rope slings by *American Chain & Cable Co.* are displayed in color on a chart which lists applications through sketches, construction features, and lifting capacities.

(28) BITUMINOUS MIX PLANTS: Three 8-page bulletins from *Pioneer Engineering Works Inc.* describe the Continuflo bituminous mix plants in three sizes with capacities from 40 up to 150 cu yd per hr. A companion unit, the Vibromatic bituminous paver is also available.

(29) SOCKET SCREWS: Unbrako fasteners are illustrated with specifications in a revised 30-page catalog of standard Unbrako items by *Standard Pressed Steel Co.* Revisions include the introduction of a new kit of socket screw keys containing 11 keys in sizes from 0.050 to ⅜ in. Dimensions of the SPS fasteners, dowel pins, and socket screw keys are shown in precision drawings and photos.

(30) "AUTOMATION—WHAT'S AHEAD?: Survey results of a study on the effects and future of automation are available in a 12-page brochure from the *American Society of Tool Engineers.* The ASTE survey learned that industry today sees automation applicable to 16 pct of all manufacturing operation in the metal-working industries.

(31) LATHES & SHAPERS: *Logan Engineering Co.* has a 24-page catalog listing a complete line of lathes, shapers, and accessories. Screw-cutting and turret model lathes are offered in V-belt or variable speed drives. Cabinet models have built-in tool storage compartments.

(32) SET-UP KITS: Time savers for set-up of milling machines, jig borers, drill presses and other machine tools are offered in a new folder from *Jergens Tool Specialty Co.* Jergens Tee Set kits and set-up blocks are illustrated with detailed specification lists.

MAIL THIS CARD

for more information on items described in Manufacturers News and for bulletins and catalogs listed in the Free Literature section.

8

Mining Engineering **29 West 39th St.** **New York 18, N. Y.**

Not good after Nov. 15, 1956—if mailed in U. S. or Canada

Please send { More Information ☐ / Price Data ☐ / Free Literature ☐ } on items circled.

Name________________________Title__________

Company________________________________

Street__________________________________

City and Zone____________________State__________

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51	52	53	54	55	56	57	58	59	60
61	62	63	64						

Students should write direct to manufacturer.

(33) AIRBORNE MAGNETOMETER: Results of an 805-mile airborne magnetometer flight over N. Africa and Portugal are offered in a paper from *Aero Service Corp.* Procedure and interpretation of the survey are detailed with maps and diagrams for a total of 665 linear miles over N. Africa and 140 miles over Southwest Portugal.

(34) SOLENOID VALVES: Latest designs of ASCO 2, 3, and 4-way solenoid valves are pictured in Catalog 201 from *Automatic Switch Co.* Prices are included in the 32-page listing of engineering information, flow charts, operation and construction details.

(35) ALUMINUM DIGEST: A compact monthly publication covering aluminum news by condensing articles which appear in the technical press is offered by *Reynolds Metals Co.* "Reynolds Aluminum Digest" has 32-36 pages each month containing 50 to 60 reviews of recent articles on the industry's current developments. A news section carries related current events, statistics, and patent listings.

(36) DRUM SEPARATOR: WPD is a wet drum magnetic separator designed for efficient recovery of media in heavy density plants. Permanent Alnico magnets eliminate cost of rectifier or motor generator set and provide correct flux distribution for positive transport of collected magnetics to the discharge point. Bulletin 87 from *Stearns Magnetic Inc.* gives complete data.

(37) GEARMOTORS: Syncrogear motors by *U. S. Electrical Motors Inc.* are listed in full-color Bulletin 1880 with ratings from 1/3 to 30 hp and gear ratios up to 10:1. Solid shank pinions, elliptoidal helical gears, integral oil seal are featured. Single, double, and triple reduction Syncrogears are available. Triple reduction types embody duplex pinions which permit a division of load on each pinion.

(38) CAT ELECTRIC SETS: *Caterpillar Tractor Co.* has a 16-page brochure on "Cat Electric Sets for Power and Protection." Installations are pictured and discussed are generator advantages of compactness, reliability, ease of operation and maintenance.

(39) CONVEYOR BELTS: Wissco standard belts by *The Colorado Fuel & Iron Corp.* are flexible moving steel platforms of open mesh construction to allow full circulation and drainage. Belts for special needs may be selected by the use of a simplified plan which is given with complete specifications in a new booklet.

(40) ELECTRONIC WELDER CONTROL: Cycles of power line frequency are counted to control welder sequence in the *Sciaky* electronic-counter welder control. Resistance welding is simplified by the control which is intended for absolute weld consistency and positive reproducibility. Sections on maintenance simplification, functional dial calibration, and a new rectifier peaking transformer firing system are given in Bulletin 338.

(41) WEATHER-PROTECTED MOTORS: Mechanical features of *Allis-Chalmers* "Weather-Protected Motors for Outdoor Installation" are portrayed in a new bulletin by means of a cross-section diagram of a typical 700-hp, 2300-v, 1185-rpm squirrel-cage induction machine. Protected motors are available in all commonly used ratings from 250 hp and up in both horizontal and vertical models.

(42) COPPER-MOLYBDENUM MILLING: *Denver Eqpt. Co.* has a 4-page bulletin that describes the Cia. Minera Benwilco milling plant in Mexico. Plant is engaged in recovering molybdenum and copper at a rate of 80 tpd. Included are a flowsheet, description of reagents used, operating results, size and arrangement of equipment.

(43) WIRE SCREENS: Revised Bulletin 67 from *Simplicity Engineering Co.* covers a complete line of woven wire screens for repair and replacement. Fabrication methods, types, designs are shown with a number of new sizes now available.

(44) BRONZE BEARINGS: *Amplex Div.* of Chrysler Corp. offers "the largest selection of sizes of self-lubricating bronze bearings available from any source." New Stock List S-56 gives the dimensions of Oilite bearings ranging in size from ⅛-in. to 4-in. inside diameter. Included is a selection of cored, bar, and plate stock and six pages of engineering data. Oilite bearings are claimed ideal in applications where proper lubrication maintenance is uncertain, impossible, or difficult.

(45) FLOTATION INDEX ADDENDUM: *Dow Chemical Co.* has issued "The 26th Annual Addition to the Flotation Index," a bibliography of articles of special interest to the mining and milling industry which appeared in 1955. Compiled from world-wide mining publications, the 1955 index lists articles on flotation research, including chemistry and theory of flotation and flotation reagents, mineral dressing, heavy-media separation, and milling operations.

(46) VIBRATORY EQUIPMENT: A permanent magnetic drive system eliminating rectifiers and the use of sliding or rotating parts is an advantage claimed for the HI-VI line of vibratory feeders by *Eriez Mfg. Co.*

(47) WELDIRECTORY: A welding directory for stainless steels, nonferrous metals, cast iron, and manual hardsurfacing from *Lincoln Electric Co.* has 28 pages of information on application, properties, and procedure for its various electrodes. A handy hardsurfacing guide comparing physical properties and cost of electrodes is also given in their bulletin, SB-1352.

(48) TITANIUM VS. CORROSION: Data on the corrosion resistance of titanium and suggestions on the application of the metal for product designers are offered in a bulletin from *Mallory-Sharon Titanium Corp.* Titanium's superior resistance to many industrial chemicals, sea water, stress corrosion make for savings in cost in many applications.

(49) TRANSOMETER: Bulletin 301 from *Askania Regulator Co.* has six pages of features and applications on the Askania Transometer which provides accurate metering for measurement and control of fuel oil and other liquids. The device is comprised of a positive displacement type flow meter and a pneumatic signal transmitter. Ranges, specifications, and performance features are included.

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GM DETROIT DIESEL 300-HP SERIES 110 ENGINE

Now available to fit a broader range of power equipment

Now the best 300-horsepower Diesel is even better than ever—ready to step up production and cut costs in any job you name.

It's the time-proved General Motors Series 110 Diesel, newly equipped with a side-mounted blower similar to the one used on the famous 71 Series. It's a more compact engine. It's shorter. It's lower. It fits more applications than ever before.

You can have this new GM Detroit Diesel Series 110 engine installed in off-highway trucks and move bigger loads faster.

You can use it to increase the power of heavy crawler tractors and scrapers—get more work per day and per dollar.

And, in practically no time at all, you can have this new Series 110 Diesel installed in almost any 3-yard shovel—to move earth faster at less cost.

The new blower makes the Series 110 Diesel engine far more versatile—available with *either* right- or left-hand rotation, and wider range of accessory-drive outlets—*four* accessory drives on the rear of the engine and *four* fan-mounting positions on the front.

This new Detroit Diesel Series 110 engine takes on all comers in operating efficiency. It's a leader in work output per dollar. Let your local GM Detroit Diesel Distributor or Dealer show you what we mean.

Single Engines . . . 30 to 300 H.P. Multiple Units . . . Up to 893 H.P.

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America's Largest Builder of Diesel Engines

ALLIS-CHALMERS NEW

TS-260 Motor Scraper

200 HP

11 YD (STRUCK)	14 YD (HEAPED)

power-matched for low-cost dirt

Power-Matched to capacity. With more than 18 horsepower for every yard of struck capacity, the new TS-260 has plenty of power to move loads at full speed—under all conditions.

Power-Matched to strength. The TS-260 has the structural strength and balance to effectively utilize all of its horsepower . . . with extra capacity built into the clutch, transmission, final drives and drive axles . . . and with a heavy, all-steel, box-type tractor frame.

Power-Matched for speed. With plenty of engine power, the TS-260 loads fast, hauls fast, dumps fast . . . moves big payloads at low cost, even under tough conditions.

Power-Matched for operating ease. Overlapping gear speeds in all four gear ratios reduce gear shifting, speed work cycles. And with 90-degree steering for rapid maneuvering in close quarters, it's easy for the operator to get the most out of the TS-260.

"Live-action" hydraulics for sure control. Gear-driven pump provides constant power for steering and scraper operation.

Positive 90-degree steering for close-quarter maneuverability. A 30-degree turn of steering wheel directs full pump flow to two double-acting steering jacks for fast, positive turns up to 90 degrees. For slow turns, a slight turn of the steering wheel provides smooth response.

"Boiling action" loading for big payloads. Curved bowl bottom and offset cutting edge team up to build heaped loads fast.

Quick, clean spreading with high apron and forced ejection. Apron moves ahead and up when ejector goes forward . . . providing high apron lift and exceptionally large opening.

Big 200-horsepower Allis-Chalmers diesel engine. Here is plenty of reserve for low-cost operation . . . plus "follow-through" combustion for smooth, steady performance.

New easy-shifting transmission. New clutch brake and gear overlap make it easy to shift smoothly, maintain steady acceleration and full pulling power.

Heavy-duty power train. The engine, clutch and constant-mesh transmission are assembled as a unit to assure accurate alignment. Simplified removal of each individual component provides easy serviceability.

ALLIS-CHALMERS, CONSTRUCTION MACHINERY DIVISION, MILWAUKEE 1, WISCONSIN

Get all the facts from your Allis-Chalmers dealer . . . now!

ALLIS-CHALMERS

Here's the drill you need for LARGER, LOWER-COST BLASTHOLES

Joy 60-BH Drill in operation in a large Southwest copper mine.

the JOY 60·BH Super Heavyweight Champion

For high-production open pit mining of copper, as illustrated above, large-diameter blastholes are a *must!* The way to drill those large-diameter holes economically—either in copper ore, or in any other open-pit mining or overburden removal job—is with the Joy 60-BH Super Heavyweight Champion. Here's why: because this Joy rotary drill excels in all three of the features which determine bit penetration:

ROTATION—Infinite variation of bit speeds, accurately controlled bit speeds, more power on bit rotation, and constant indication of bit speed and pressure by gauges.

BIT WEIGHT—The Joy hydraulic feed, using two 5-foot hydraulic cylinders, is the most efficient and dependable method of applying bit pressure. It is more accurately controlled and less hazardous than other methods.

CUTTINGS REMOVAL—Only Joy uses a heavy-duty, industrial-type, water-cooled air compressor to insure more dependable air supply required for efficient rotary-air blast drilling.

Other features include a self-aligning hydraulic automatic chuck, hydraulically raised and lowered derrick, and rod handling device.

The 60-BH, capable of drilling 9″ to 12″ diameter holes in even the hardest rock formations, is the largest in the outstanding line of Joy Champion "rotary-air blast" drills. Smaller models are the 58-BH Heavyweight for 7⅞″ diameter holes, and the 56-BH Middleweight for 6¼″ diameter holes. Let us quote on *your* requirements. *Joy Manufacturing Company, Oliver Building, Pittsburgh 22, Pa.* In Canada: *Joy Manufacturing Company (Canada) Limited, Galt, Ontario.*

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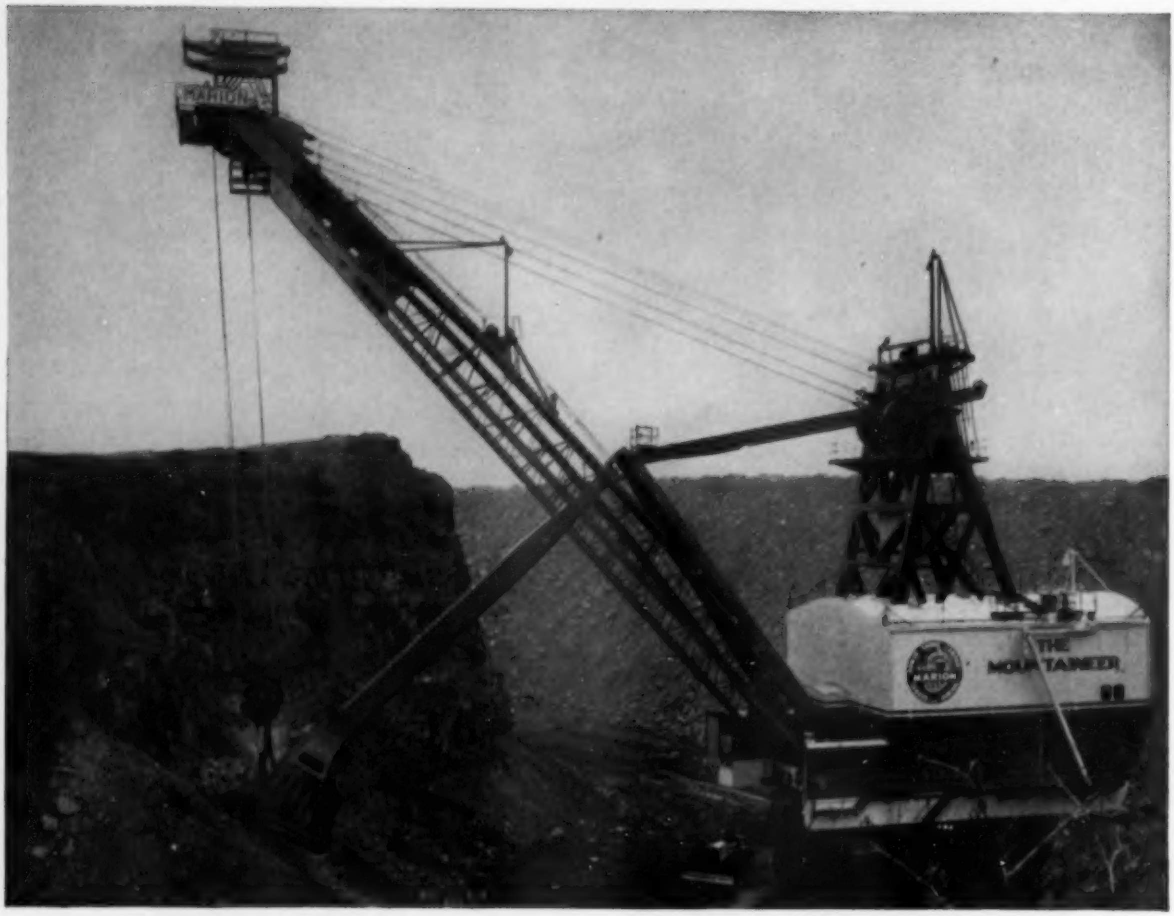
JOY

WORLD'S LARGEST BUILDER OF CORE DRILLS, ROTARY BLAST HOLE DRILLS AND MOTORIZED DRILL RIGS



World's Largest Shovel is the Mountaineer, built by Marion Power Shovel Co. for Hanna Coal Co. It is 16 stories high, and scoops up overburden in 90-ton bites. USS "T-1" steel is specified for such major components as the bucket, dipper stick and crowd rack; to assure the strength, toughness and ruggedness that adds up to long service life.

"T-1"...a super-tough nickel alloyed steel prevents breakage...slashes downtime

At 38°F below zero...or at 900°F above..."T-1" steel stays *super-tough!*

Downtime troubles *go out* when "T-1" steel *goes in* dipper sticks, shovel buckets, car bottoms, bulldozers and other mining equipment.

That happens because "T-1" steel is a constructional alloy steel combining exceptionally high levels of strength and toughness. It stands up under heavy shock loads. Curbs breakage the year 'round.

Note its advantages:

90,000 psi minimum yield strength.

Readily weldable . . . needs no preheat nor stress relief.

Resists impact at sub-zero temperatures.

Four times as resistant as carbon steel to atmospheric corrosion.

Use "T-1" steel for heavily stressed parts. Watch them stay on the job, earning profits. Why take chances with steel of lower yield strength and consequent risk of failure in service? Idle men and machines make it a costly proposition...so, put "T-1" steel to work now.

For details on USS "T-1" steel, write to United States Steel Corp., Pittsburgh 30, Pa.

INCO TRADE MARK **THE INTERNATIONAL NICKEL COMPANY, INC.** 67 Wall Street New York 5, N. Y.

PRINTED IN U.S.A.

Half Billion in Uranium Contracts Held by Rio Tinto of Canada

Rio Tinto Mining Co. of Canada Ltd. announces that the largest single uranium contract to date has been awarded to Northspan Uranium Mines Ltd., a company under Rio Tinto management; and the negotiation brings to more than $500 million the total value of uranium contracts now held by companies under the management of this firm. Northspan resulted from amalgamation of three major companies of the Blind River (Algoma) region of northern Ontario: Lake Nordic Uranium Mines Ltd., Spanish American Mine Ltd., and Panel Consolidated Uranium Mines Ltd. Northspan has received a letter of intent from a Canadian government agency for the purchase of over $242 million worth of U_3O_8 and will attempt a record production rate of 9000 tpd.

Texas Zinc Minerals Buys Happy Jack Mine

Texas Zinc Minerals Corp., jointly owned by New Jersey Zinc Co. and the Texas Co., has purchased the Happy Jack Mine in southeast Utah for an unannounced price. Company has also begun construction of a uranium processing mill at Mexican Hat, Utah, about 70 miles from the mine. Capacity of the mill, scheduled for completion in September, 1957, was also not disclosed.

Columbium Discovery Clued by Airborne Survey

A major deposit of columbium ore in northern Ontario has been found by Dominion Gulf Co., a subsidiary, of Gulf Oil Corp., after investigation of a region that showed promise during airborne magnetometer reconnaissance. More than 16,000 ft of drilling has been done and Gulf says geologists are convinced that the area, near Chapleau, is one of major importance.

Speeding of Philippine Nickel Production Urged

ODM is pressing to reduce the estimated four to five year lead time before substantial Philippine nickel production can be achieved. Deposits of the Surigao area are large and the nickel wealth of the islands is estimated to be fifth largest in the world.

Phelps Dodge to Drill in Wyoming

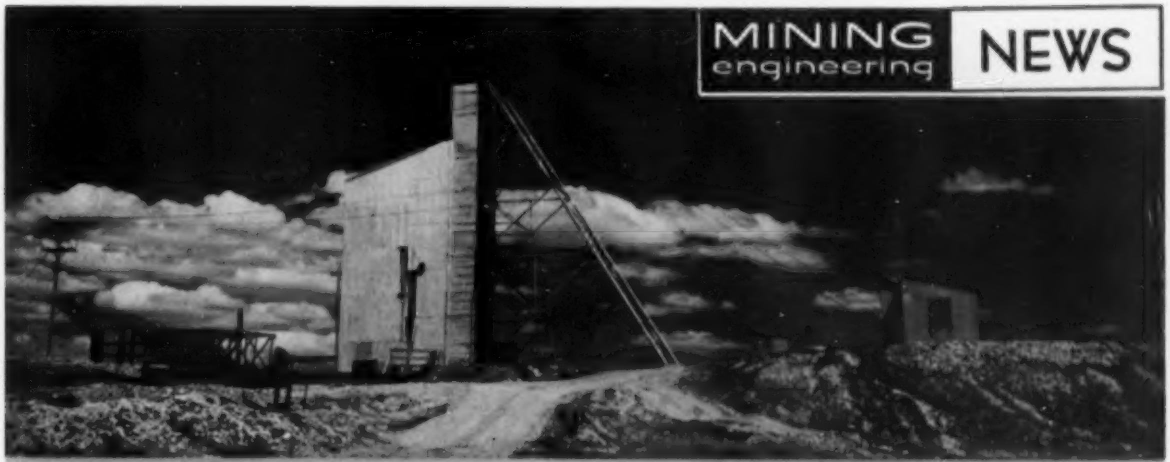
During the current year Phelps Dodge Corp. plans to drill 68,000 ft of exploratory hole on uranium properties in the Crooks Gap region of Wyoming. An option merger agreement has been approved by stockholders of Wyoming Uranium Corp. which controls the properties.

Output Started at Three International Minerals Plants

International Minerals & Chemicals Corp. has begun operations at three new units. Annual capacity of a Blue Mountain, Ont. mine and plant producing nepheline syenite, used in glass making, is an expected 100,000 tons. New mica beneficiation plant at Greenville, Tenn. has a capacity of 64 tpd. A perlite grinding unit in Los Angeles has also been established and it is planned that present capacity will be doubled.

Boron Chemical Processing Put On Large Scale

Boron trichloride, an essential base for the manufacture of high energy fuels and missile propellants, will be manufactured in "substantial tonnage" when Stauffer Chemical Co. completes a ten-fold expansion of its Niagara Falls facilities.



GILSONITE

Hydraulically Mined — *Hauled Via Pipeline*

The first, large-scale, privately financed project in the world to produce conventional petroleum products from a raw material other than crude oil was announced July 11 by the American Gilsonite Co. of Salt Lake City.

The company has perfected a process for converting the unique, solid hydrocarbon mineral *Gilsonite* into high purity electrolytic coke for the aluminum industry and high octane gasoline.

The $16 million project involves a new processing plant to be completed in the spring of 1957 and the laying of one of the world's largest pipelines for transporting a solid material to link up mines in Utah with a new refinery near Grand Junction, Colorado. Every phase of the undertaking—mining, pipeline, and processing plant—will be characterized by distinctive features. Work on all three phases has been started, as follows:

(1) At Bonanza, Utah, in the Uintah Basin, center of the company's mining operations since 1904, where new *wet* mining techniques are being used;

(2) Over the intervening 71 miles of rugged mountain terrain, where a 6-in. pipeline is being laid for transporting the Gilsonite in suspension from Bonanza to the Grand Junction plant. In the Book Cliff Mountains of Colorado at Baxter Pass, the pipeline will attain a maximum elevation of 8492 ft, and;

(3) At Gilsonite, Colorado, a newly-named location near Grand Junction where the processing plant is being located on a 1200-acre site. Plant will eventually handle more than 600 tons of Gilsonite daily and employ 125 persons.

Geology of Gilsonite

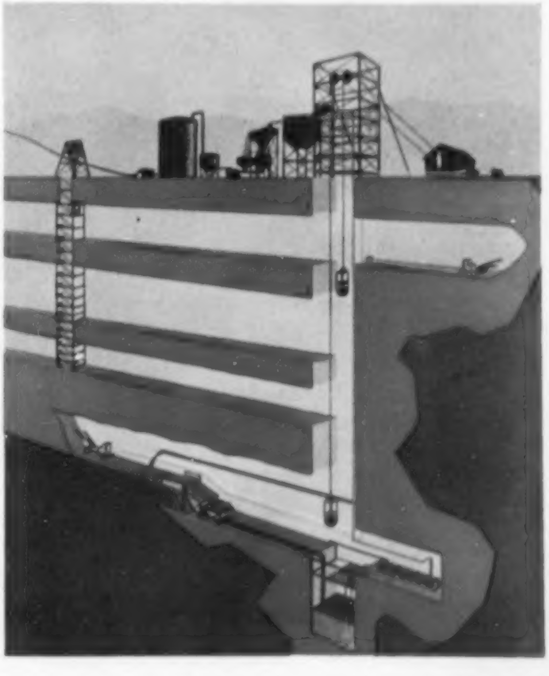
Principal veins of Gilsonite (*Uintaite*) are located in the Uintah Basin of eastern Utah and western Colorado. The ore is related to Wurtzilite, Ozocerite, and Grahamite found in the same general area and is an asphaltite having high resin content and very little sulfur.

Its precise origins are uncertain. The most accepted explanation is that it was formed from the partial decomposition of organic material in shale formations, much in the same way that oil was formed. However, massive upheavals of the shale squeezed this organic material upward into stress cracks formed in the overlying beds of sandstone. During intervening millions of years, the liquid organic material was changed, perhaps by polymerization, heat and the action of mineral catalysts, into today's Gilsonite.

Fissures strike northwest-southeast through the Uintah Basin, varying in width from a few inches to 22 ft. Outcrop of one vein may be traced for more than nine miles, and some go down as deep as 2000 ft. All of the Gilsonite deposits in the basin are enclosed in an elliptical area about 10 miles wide and 60 miles long.

Inclusions of rock are occasionally found in the ore. These rock masses are usually large and may be continuous between the walls of the vein. They are most common near an offset. Generally, a corresponding cavity can be found in the vein wall not

(Continued on page 788)



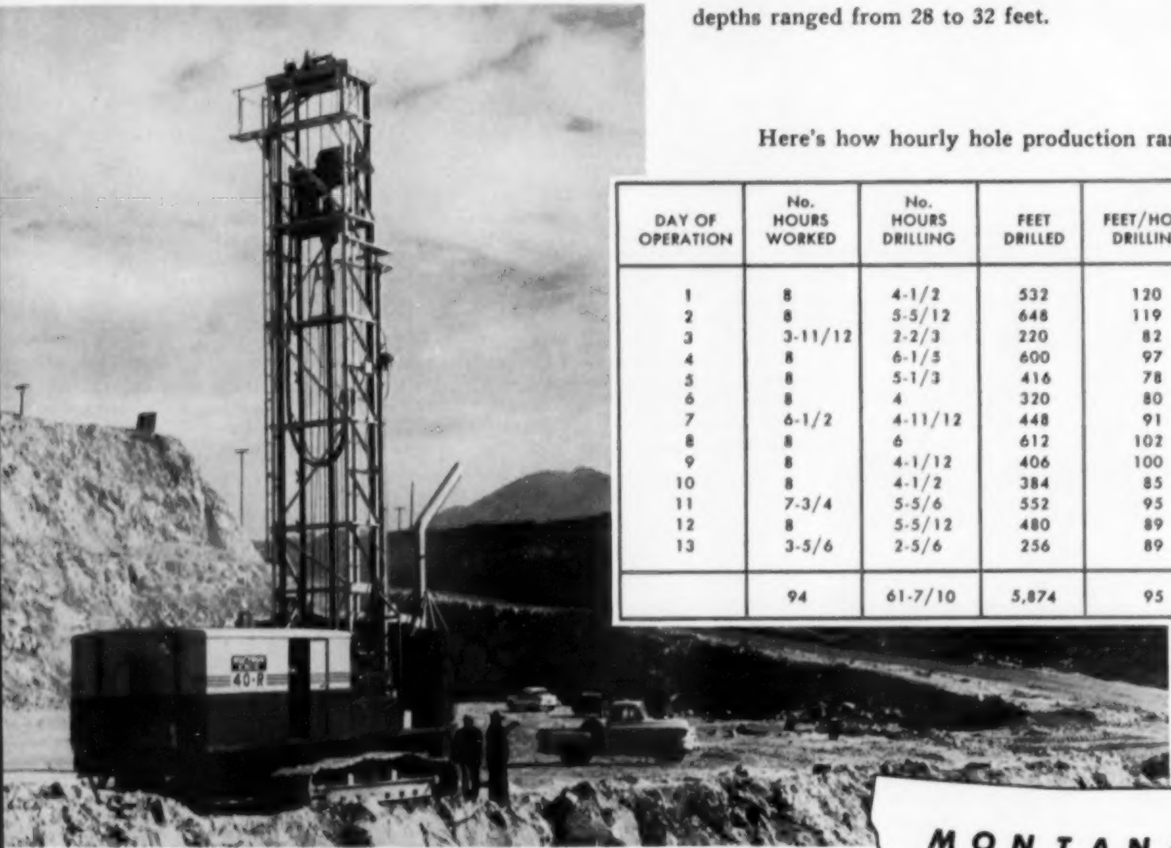
Cross-section of a Gilsonite vein showing how the new hydraulic mining methods will be applied. A vertical shaft is first sunk, and slightly sloping drifts are cut at right angles to it. Cut ore is washed to the bottom of the shaft and raised to the surface in buckets. Two new types of ore cutters are used.

Butte, Montana . . .

another example of how Bucyrus-Erie rotaries cut costs on big-volume stripping jobs

F & S Contracting Company and Morrison-Knudsen Company, Inc., joint venture stripping contractors on a large Montana copper property, have adopted a modern high-speed drilling program which allows maximum economy in use of shovel loading and truck hauling units. The drill chosen to meet their needs was this electrically powered Bucyrus-Erie 40-R rotary.

According to F & S officials, the 40-R has worked so rapidly that it has stayed ahead of a 6-yd. shovel, even when operating less than a full shift each day. Drilling procedure consists of putting down 9-in. diameter holes spaced on 21-ft. centers. A daily log for the initial period of operation shows the 40-R drilled 5,874 feet of hole through decomposed granitic rock in 62 hours drilling time — a rate of 95 feet per hour. Hole depths ranged from 28 to 32 feet.



Here's how hourly hole production ran:

DAY OF OPERATION	No. HOURS WORKED	No. HOURS DRILLING	FEET DRILLED	FEET/HOUR DRILLING	FEET/SHIFT HOUR
1	8	4-1/2	532	120	67
2	8	5-5/12	648	119	81
3	3-11/12	2-2/3	220	82	56
4	8	6-1/5	600	97	75
5	8	5-1/3	416	78	52
6	8	4	320	80	40
7	6-1/2	4-11/12	448	91	69
8	8	6	612	102	77
9	8	4-1/12	406	100	51
10	8	4-1/2	384	85	48
11	7-3/4	5-5/6	552	95	71
12	8	5-5/12	480	89	60
13	3-5/6	2-5/6	256	89	66
	94	61-7/10	5,874	95	62-1/2

When excavation quantities run high, the fast, large-diameter hole making ability of Bucyrus-Erie rotaries really pays off. Let us tell you how they can cut preparation time and drilling costs in your operations. Write today for detailed, illustrated literature. Model 40-R drills 6-3/4 to 9-in. holes and is available with either diesel-electric or full electric power. Model 50-R drills 9-7/8 to 12-1/4-in. holes and is electrically powered.

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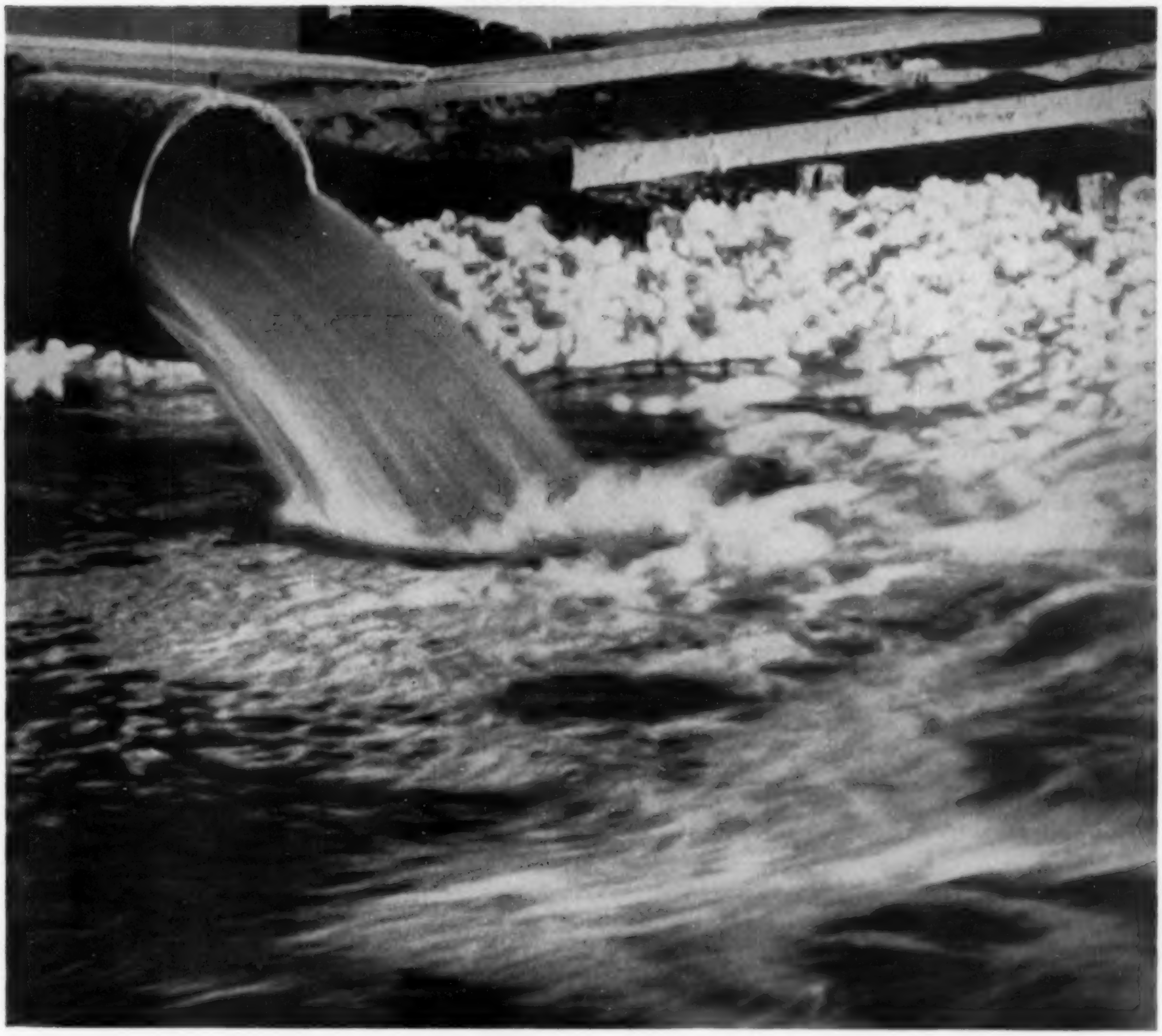
South Milwaukee, Wisconsin

76th YEAR OF SERVICE TO MEN WHO SHAPE THE EARTH



$1,000 a day down the drain

In one of the major processes for the recovery of cobalt and nickel, salts of these metals are precipitated chemically from the primary ore leach liquor, then filtered. Unfortunately, precipitation is always incomplete. The result? Just about a thousand dollars' worth of metal is being lost daily.

The metals can be saved, however—by a process based on AMBERLITE® ion exchange resins. Virtually all of the unprecipitated cobalt and nickel salts can be readily extracted from the filtrate and returned to the leach circuit.

Cobalt and nickel are but two of the metals which can be won from ores or scavenged from wastes by ion exchange. Uranium is being processed with AMBERLITE ion exchange resins. Rare earth elements can be recovered from complex ores. Rhenium can be salvaged from refinery flue dusts, and nickel and chromium can be recovered from plating rinse water.

Can ion exchange help you? To find out, and to keep abreast of developments in ion exchange, ask for the bi-monthly report, Amber-Hi-Lites.

Chemicals for Industry

ROHM & HAAS COMPANY

THE RESINOUS PRODUCTS DIVISION

Washington Square, Philadelphia 5, Pa.

Representatives in principal foreign countries

. . . *gilsonite*

(Continued from page 785)

more than 50 ft above the rock inclusion, indicating that the Gilsonite was quite viscous at the time the rock was dislodged. Veins in the Bonanza area entering the Green River shales break into small irregular stringers, which are presently uneconomical to mine.

Hydraulic Mining Methods

Mining the unique mineral has always presented problems.

Earliest method was to pick away at the ore, letting it roll down an incline, where it was loaded into buckets and hauled to the surface. Until recently, most Gilsonite was mined by mechanical modifications of this method. Although it will not burn in the solid state, Gilsonite dust is highly explosive and presented a danger in the old methods.

Two new wet mining methods have been developed by the company over the past four years. Both methods reduce explosion hazards and the need for hand labor.

Into a Gilsonite vein at least six ft wide, a shaft is sunk to over 850 ft. Drifts are next cut on either side by means of a jet cutting car equipped with one of two types of cutting heads. Where the ore contains tiny fractures, a powerful jet of water, issuing from a ¼-in. nozzle, with a pressure of 2000 psi, is played on the ore surface. The water stream penetrates the fissures and the ore breaks apart and falls to the bottom of the drift which is cut on a rising grade of about 2½ deg. Freed ore is washed to the main shaft, down the shaft and across a dewatering screen where lumps above ¾-in. size are separated from the water. These are lifted to the surface in a two-compartment hoist. The water and minus ¾-in. ore are pumped to the surface with centrifugal pumps.

Stulls are used for wall support in narrow, mined-out Gilsonite veins. Orebodies outcropping like that shown above have been already mined and the search for ore has gone underground.

Another ore-cutting tool consists of a long rotary drill armed with carbide-tipped teeth. The drill cuts a large swath, and streams of water pour out through the teeth to keep the ore constantly wet. Again the ore is washed to the main shaft. Both types of cutting tools are mounted on a chassis which moves on four rubber-tired wheels and is operated by air power. Mounted on it are two hydraulic booms similar to drilling jumbos. These support and guide the cutting tools.

When a drift is completed, the cutting machine returns to the shaft and begins a new drift. Every 50 ft of depth, a floor will be installed for overhead protection. Walls will be almost solidly timbered and, about every 350 ft of depth, a pillar of ore about 30 ft thick will be left horizontally between the walls for major strengthening.

At the surface, ore not destined for the refinery is crushed and again introduced into the water and flows by gravity pipeline to a drying plant at Bonanza. The dried product is again screened to various sizes required for the trade.

Ore to go to the refinery is dewatered, dumped into a bin, and

(Continued on page 790)

. . . gilsonite

(Continued from page 788)

then recombined in a tank with a portion of the washwater from below ground. This slurry is prepared in the proper pumping proportion and then cleansed.

After cleaning, the material will be stored in 5000-bbl tanks. The tanks will be agitated to keep the material suspended, and from them the slurry will be pumped through a pipeline to the refinery more than 70 miles away.

Pipeline Operation Details

Prepared slurry will travel in a 6-in. pipe buried beneath the frost-line.

First obstacle met by the pipeline is the White River in Utah which supplies water for the mining and pipeline operation. A 600-ft suspension bridge will be built to span White River Canyon and carry the pipe over its waters. Pipeline will then traverse rugged country at Evacuation Wash, and there a second suspension bridge will take the line to the headwaters of the wash near Baxter Pass. From the pass, the path is all downhill to the refinery site at Gilsonite, Colo. The grade on the line will be kept to a flat slope to eliminate the possibility of plugging.

At the Bonanza pump station there are three electric pumps. Two will be operating and one will be at standby. In addition, there will be a water reservoir at the top of Baxter Pass that will be used to flush the line should the flow stop for some unforseen reason.

Much research went into the design of the pipeline. A pilot model was built at Golden, Colo., at the Colorado School of Mines Research Foundation Inc. Here, a radioactive section of pipe was included in the test line. By measuring the radioactivity of the slurry in the effluent, it was possible to determine with the highest accuracy the corrosion and wear that was taking place within the test pipeline. By removing free oxygen from the slurry with sodium sulfite, corrosion was almost eliminated.

Processing

By injecting a small amount of oil into the pipeline upstream from its discharge point at the refinery, the Gilsonite is separated from the pipeline water. Gilsonite has an affinity for oil which causes the small particles to agglomerate and, since it is hydrophobic, it can be separated by filtering or centrifuging.

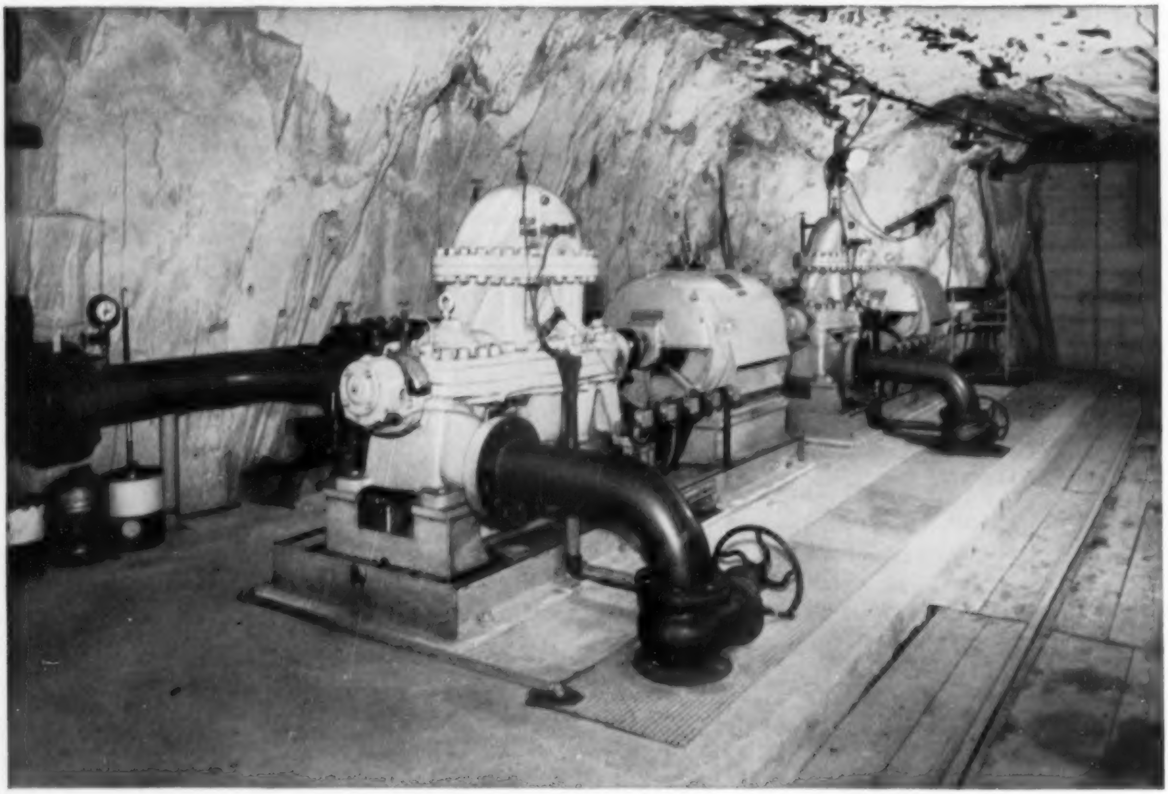
Using a delayed coker, a fractionator, and a catalytic reformer, the plant will convert the brittle material into 50 (weight) pct green coke, 35 pct gasoline, and 15 pct 1400 Btu gas which will be used as plant fuel. While initial coke output will be 250 tpd, the plant is designed to accept an increasing charge which will allow an output of 550 tpd.

The gasoline, after reforming, will be finished and blended for marketing in Western Colorado, now served from distant refineries. The coke will be calcined and shipped in covered hopper bottom cars primarily to markets in the northwestern part of the U. S. Pipeline water will be clarified and used for process cooling.

The new plant is expected to have a salutary effect on the economy of the Grand Valley in western Colorado. The Grand Valley is principally an agricultural region although Grand Junction, its largest city, is in the midst of a uranium boom and is headquarters for the AEC's ore procurement division and numerous uranium mining, refining, and allied companies.

The Grand Valley was chosen as a plant site because it has railroad facilities (the mines at Bonanza have none), it is sizable enough to offer a suitable market for the gasoline product, and it offers the shortest pipeline haul from the mines.

Ingersoll-Rand Mine Pumps



Two 6-stage Ingersoll-Rand drainage pumps in the Star Mine at Burke, Idaho. Other I-R pumps in this mine include two 300 hp and two 250 hp multi-stage units, as well as numerous Motorpumps.

...meet exacting demands of drainage service at Star Mine of Bunker Hill Company, operated by Hecla Mining Co.

Installed on the 4000 ft. level of the Star Mine at Burke, Idaho, the two I-R pumps shown above boost water to the 2000 ft. or drainage level of the mine. Driven by 700 hp motors and rated at 1000 gpm each, 2050 ft. head, these units have been giving excellent service.

In the Coeur d'Alene mining area, in which the Star Mine is located, the traditionally fine performance of Ingersoll-Rand mine pumps has resulted in their selection for handling more than 95% of the mine water pumped. The exceptional service record of these units reflects Ingersoll-Rand's many years experience in the design, construction and application of pumps for mine drainage service.

Discuss your next pumping application with your nearby I-R representative. He is qualified to furnish complete information and recommendations.

Ingersoll-Rand

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COMPRESSORS • GAS AND DIESEL ENGINES • ROCK DRILLS • PUMPS • TURBO-BLOWERS • AIR AND ELECTRIC TOOLS

USBM FUNDS

SECRETARY of the Interior Fred A. Seaton announces that Congressional appropriations for the U. S. Bureau of Mines for fiscal year 1957 will enable it to intensify nationwide research in metals and nonmetals necessary to defense and industrial progress. Funds totaling slightly more than $22 million were made available for conducting field studies and for maintaining experiment stations and laboratories in 27 states and Alaska.

Mining research will be put into high gear and will be expanded and directed toward establishing and developing engineering principles that will promote safer and more efficient mining practices. This work, to be conducted in close cooperation with industry and with other research organizations, will cover every phase of mining. It will include investigations of methods and costs of both underground and surface mining of all nonfuel minerals, research on rock mechanics, drilling and blasting, studies of ore-sampling theories and practices, and area research on major mineral resources.

Capsule rundowns on some of the intended studies follow:

Smelting characteristics of various iron ores and agglomerates will be investigated and basic study will be made of high-temperature reactions. Research on iron ore will be speeded to find ways of rapidly meeting increasing demands for pig iron and steel that have depleted domestic direct-shipping ores. USBM will investigate iron ore deposits in the North-Central Western states and conduct laboratory studies to develop methods of beneficiating low-grade materials in Arizona, California, Colorado, Minnesota, New Mexico, Nevada, Oregon, Utah, Washington, and Wyoming. Further research on beneficiating and agglomerating low-grade red ores and iron-bearing sandstones of the Southeast will be intensified.

Use of off-grade chromium materials will be given a closer look and other studies will be aimed at developing low-cost methods for producing high-purity vanadium as a byproduct of uranium milling operations.

Field investigations and laboratory studies will be combined to obtain information on the quality and extent of U. S. titanium mineral reserves. Such work will help assure continued expansion of the already rapid growth of titanium metal and titanium pigment industries. The Bureau will also enlarge its laboratory and pilot-plant studies to reduce costs of producing high-purity titanium metal. Supply-demand situations of titanium, aluminum, and magnesium will be frequently evaluated during 1957 to provide industry and federal planning agencies with information to assure sufficient production capacity and supplies in case of emergency.

USBM also plans to expand its research in copper, lead, and zinc. Known reserves will be evaluated and the search for new ore sources hastened. More effort will be made to develop better mining techniques to help domestic mines to improve their competitive position. Since the copper industry requires the handling of huge tonnages of low-grade ore cooperative research projects at several of the largest U. S. copper mines have been alloted additional funds.

Although increased supplies of columbium, tantalum, beryllium, and selenium have resulted from studies made to date, mining and metallurgical research will be continued on these four metals and on the rare earths.

Analytical and advisory services on coal for other government agencies will be carried on by USBM and continued work will be done in mining, preparation, combustion, gasification, and use of low-rank coals. Emphasis will be placed on improving methods and equipment for washing and dewatering fine sizes of coal. Further work will be done on the design of equipment for gasifying lignite and a study will be made of the carbonizing properties of several coals and mixtures not presently used for metallurgical coke.

LAND MANAGEMENT HEADACHE

MORE mining engineers and geologists are the only prescription in sight for a newly acquired U. S. Bureau of Land Management headache. Cause is recently enacted legislation increasing the scope of the minerals program, particularly the multiple-use-of-resources measure, P. L. 167, which was designed to correct abuses of the mining laws. Hearings in the thousands and claims in the tens of thousands are estimated to be involved in enforcement of these acts and BLM expects that nearly a hundred more professional employes in various categories will be needed to work in the western states and Alaska.

While the bureau does not plan to take action on all unpatented mining claims, it must examine those where there is a management conflict between surface and subsurface areas. In administering P. L. 167, BLM will check unpatented mining claims on unreserved public domain lands, search county records for ownership, notify claimants, and hold hearings.

Three other measures are also putting skids on the workload:

Public Law 357, known as the Uraniferous Lignite Act, requires the filing of location notices of unpatented claims with BLM if lignite lands containing fissionable materials are involved.

Public Law 47 prevents further mineral locations on the Papago Indian Reservation in Arizona in favor of a leasing program which cannot be fully administered by the Bureau of Indian Affairs until the validity of existing claims is determined.

Public Law 359, which is known as the Mining Claims Rights Restoration Act, opened some 7.2 million acres of lands in power site withdrawals to mining location for the first time in many years. Almost half of this area is in national forests. In case of placer claims, notice of intention to hold a public hearing must be given within 60 days after the date of filing. BLM must serve the notice, conduct necessary hearings, and issue decisions as required.

All positions offered are in the competitive civil service and about half of the work is in the field and requires travel from headquarters. Duties of the engineers and geologists needed by BLM include making technical examination of mining claims, appraising mineral values to determine feasibility of fur-

ther development, and serving as expert witnesses at hearings, if necessary.

Details can be obtained by writing to the Bureau of Land Management, attention Placement Officer, Dept. of the Interior, Wash., D. C. or to any of the four Area Offices of BLM located as follows: P. O. Box 3861, Portland, Ore.; P. O. Box 659, Salt Lake City, Utah; Federal Center Bldg. 59, Denver, Colo.; and P. O. Box 1481, Juneau, Alaska.

THE nation's needs for research in engineering will be scrutinized in a comprehensive study by the American Society for Engineering Education with the support of a special grant from The National Science Foundation. The $40,000 study will serve to pinpoint the most vital areas in engineering research. "When these needs are clearly defined, methods should readily be found to locate and provide support for these activities," said AIME member H. K. Work, vice president of the society and chairman of its Engineering College Research Council, in his announcement of the project.

Mr. Work pointed out that basic or so-called fundamental engineering research is not well supported. "Yet," he said, "this type of research is most generally accepted as a highly desirable activity for an engineering school. It fits in with the concept that a university should develop new information as well as disseminate the old."

Applied research, on the other hand, said Mr. Work, is now being adequately supported financially; but it is not generally as welcome in a university. Both types of research, applied and fundamental, will be covered by the proposed study. Both, Mr. Work said, constitute "an important part of the education of engineers."

PATTERN on the Plateau—or is the banker taking up the mortgage!

Geologists were the first arrivals, and a flock of geiger counting professional prospectors. Then the whole of the west became a free-for-all game of hot and cold for the uranium bonanza that meant a big piece of the big change that Uncle Sam had ready in his pocket. The prospectors had a new heyday that is not yet history—but mining history is repeating itself in uranium as it has always done before. The individual is squeezed out because he can't afford the drilling necessary to exploration when the outcrops are found or being successful in finding ore, he turns it over for a suitable sum to large company operation.

Not too strangely, the early years on the Plateau found a relative few of the big guns of mining and milling ready to invest in a slice of the yellow cake. Of the major nonferrous companies Climax Molybdenum was one of the first to get its feet wet. The water was fine. Now the list of enthusiastic firms splashing in the uranium puddle could collectively outbid King Midas in a tight business deal. Some of those that come first to mind follow: Anaconda Co., American Smelting & Refining Co., Union Carbide Nuclear Div., National Lead Co., New Jersey Zinc Co., Texas Co., Vitro Minerals Corp., American Metals Co., American Zinc, Lead, & Smelting Co., Phelps Dodge, New Idria Mining & Chemical Co.

Those indefatigable hole-drillers, the oil companies are showing up in their uranium working clothes too. Superior Oil Co., Kerr-McGee Oil Industries, El Paso Natural Gas Co., Tidewater Associated Oil Co., Phillips Oil, Humble Oil Co., Sun Oil Co., Cities Service Oil Co. are some of the larger ones.

When the holes get deep enough, nothing but dollar bills will reach the bottom.

STEEL supply and demand, tied to news of the steel strike dominated the business news in the early weeks of the summer. First protracted negotiations, then the strike itself were subject of hourly bulletins on radio, TV, and of plentiful press coverage.

As this page is going to press the strike has ended —and shortly there will be a summing up of cost to industry, *and to consumer*. There will no doubt be extensive price revisions for steel and, progressively, of products utilizing steel. At this date there is no widely reported pattern of strike-and-settlement developing across all industry, and hence no index of national inflationary effects is yet apparent.

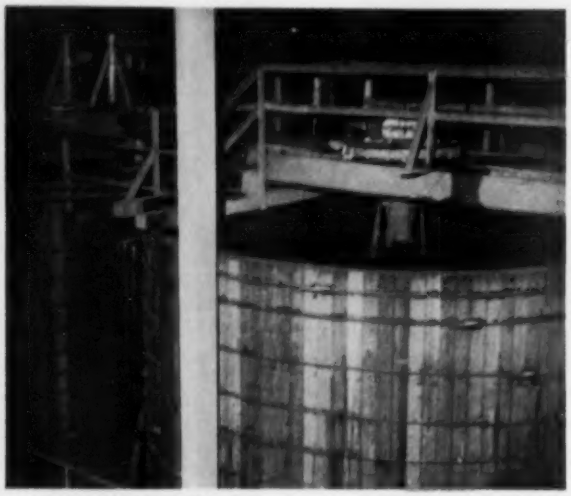
In the summing up there is already apparent an absence of major dislocations of other industry with the exception of construction. Trouble spots may yet develop—structural shapes seem to be the biggest headache now—but the auto industry, usual sufferer, had dropped output and carried heavy inventory into the strike period. It registered little effect of steel shortage.

Scope of the agreement itself, between the 12 steel companies on the one hand and the United Steelworkers on the other, is interesting. This is no place to reprint the contract but to itemize topics covered:

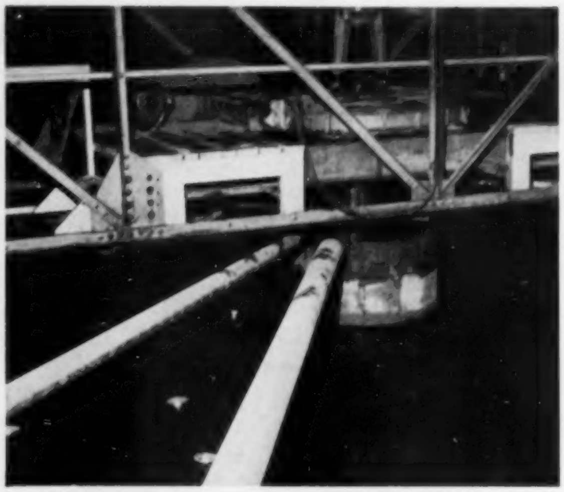
- *Wages:* An annual wage increase (about 7.5¢); a cost-of-living adjustment of 1¢ per hour for each 0.4 or 0.5 point increase in the BLS Consumer Price Index; and incentive adjustments.
- *Other pay provisions:* Sunday premium pay going from 10 to 25 pct over the three years; jury service pay; and changes in overtime rates of pay, upward.
- *Supplementary Unemployment Benefits:* A plan to be negotiated based on company contributions to a trust fund.
- *Insurance and Pensions:* A new insurance agreement to be negotiated with increased contributions by both sides; and increased pensions.

Most interesting perhaps, and the next to last item of the contract: *the term is three years, or to 1959*. Not quite a victory for either side.

Correction: In some copies of the July 1956 issue of MINING ENGINEERING, pages 746-747, the following changes should be made: A. B. Kinzel has been nominated to be AIME President-elect 1957, President in 1958; Roger V. Pierce has been nominated as AIME Vice president, not Director; and A. W. Thornton is now Chairman, not Chairman-elect of the Metals Branch.

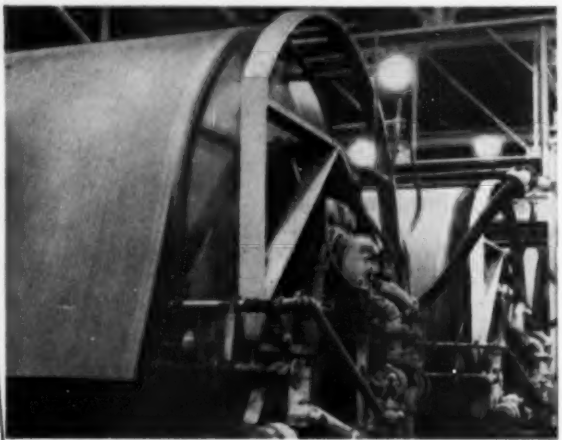


Two of the twelve Dorr Agitators installed at Gunnar.



Closeup of one of the Tray Thickeners showing drive mechanism and feeding arrangement.

URANIUM PRODUCTION AT GUNNAR MINES LTD.



Three of the six Oliver String Discharge Filters. Three additional Filters have since been ordered.

Photographs by J. Wilson, Gunnar Mines Ltd.

One of the early Uranium producers in North America, Gunnar Mines Limited at Uranium City, Saskatchewan selected Dorr-Oliver-Long equipment for above and below ground operations from our Associate Company in Canada. For the *leaching section* twelve acid resisting Dorr Agitators are installed, each 20′ dia. by 20′ deep. For the *neutral circuits* four 3-compartment Dorr Tray Thickeners are used, each 50′ dia. by 23′ deep and two 8′6″ dia. x 7 Disc American Filters. For *final residue washing*, six Oliver String Discharge Filters are employed, each 11′ 6″ x 16′ face with acid resisting construction. In the *precipitation section* is the first Rubber Lined Sweetland Filter ever built.

Now an open pit operation, Gunnar plans a new shaft in the near future and has ordered from Dorr-Oliver-Long the front dump skip, cage, head sheaves and Granby type mine cars.

For more information on the complete line of D-O equipment for the mining industry, write to Dorr-Oliver, Stamford, Connecticut.

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How a new **CAT*** No. 12 can

STEP UP YOUR MINE'S EFFICIENCY 3 WAYS

This new Caterpillar No. 12 Motor Grader maintains 16 miles of haul road and 'dozes truck spillage at the Hill-Trumbull Mine, Marble, Minn. It is owned by the Mesaba-Cliffs Iron Company and operated by the Cleveland-Cliffs Mining Company of Cleveland, Ohio. In building and maintaining haul roads for faster cycle times and reduced wear and tear on equipment, in 'dozing and clean-up work, the new Caterpillar No. 12 does a big and important job. Here is how it can do it at lower cost in *your* mine:

1. LOWER OPERATING COST. The new No. 12 delivers its 115 HP on non-premium, low-cost fuels. Its new oil clutch gives you longer clutch life, easier operation, and as much as 1500 hours between clutch adjustments. Tubeless tires (furnished at no extra cost) run cooler, last longer, and eliminate the tube and flap down time of old-fashioned tires.

2. LONGER WORK LIFE. Like all Caterpillar Motor Graders, the No. 12 is built—not just assembled—by a single manufacturer. This means traditionally sound Caterpillar ruggedness and workmanship, and careful balancing of engine and blade capacity for long life and high efficiency. And it means a single source for parts and service—your reliable Caterpillar Dealer.

3. INCREASED PRODUCTION. Positive, non-creep controls, easy "feel-of-the-road" steering, sure-footed traction with engine positioned over the driving wheels, quick-change blade positioning, unobstructed visibility—all these are good reasons why operators *like* the Caterpillar No. 12 Motor Grader, and do more efficient work on any job.

Your Caterpillar Dealer will demonstrate these and other features of the fast-working, long-lasting No. 12 Motor Grader. See him for proof that the Cat No. 12 will do more work at less cost on *your* job than any other grader.

Caterpillar Tractor Co., Peoria, Illinois, U. S. A.

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99% OF ALL CAT MOTOR GRADERS EVER BUILT ARE STILL AT WORK

AN AIME REPORT:

Implementation of Long Range Planning for Institute Development

THE purpose of AIME as set forth in its constitution is "... To promote the arts and sciences connected with the economic production of the useful minerals and metals and the welfare of those employed in these industries by all lawful means . . ." This purpose is substantially the same as that established by the founders of AIME in 1871, but the means of achieving it are decidedly different. There were twenty-two founding members; there are more than that many thousand members at present and almost three times that many persons employed on the Institute staff. There are almost a dozen different technical specialties within the Institute and over seventy groups of members organized as local sections. Consequently, the organization of AIME today must be substantially different from what it was in 1871, or even a decade ago. The organization must continually be adapted to the needs of the membership. Over the years this has been the policy of the Board of Directors. For example, in 1911 local sections were authorized, the first three being New York, Boston and Spokane. In 1912 the Iron and Steel Division, the prototype of the technical committees, was authorized, and in 1914 the following technical committee had been formed: Iron and Steel, Precious and Base Metals, Mining Geology, Mining Methods, Nonmetallic Minerals, Coal and Coke, Mining Law, Petroleum and Gas, and Use of Electricity in Mines. In 1913 the Bylaws were changed to permit formation of "professional groups to be known as Divisions of the Institute." However, it was not until 1918 that the first professional Division was formed.

In 1948, as a result of the Johnson Committee's study of the Institute's organization, the three present branches of the Institute were organized. These changes were largely good, and great progress has been achieved under them, but new problems and new methods of operation have been developed during the past decade which are not adequately provided for under the present Institute structure. As these three branches grew in stature through service to the members, they have become more and more the units of the Institute with which members affiliate professionally. This growth indicates that these units should be given greater responsibility and authority to handle their own problems. Furthermore, with the formation of some local sections as professional as well as administrative units, additional organization changes seem advisable.

The AIME Board recognized these changes, and at the beginning of 1955 appointed a committee of three senior members known as the Long Range Planning Committee to study them and propose an organizational structure that would meet current as well as future needs. The official report of this Committee was presented at the last Annual Meeting of the Institute in New York and published in recent issues of the AIME journals. The Committee proposed basically that the three present branches be converted to societies with more responsibility for operations placed in their hands. A sub-committee was then appointed to study the Long Range Planning Committee Report. Their assignment was to recommend to the Board what steps should be taken to implement or reject the several recommendations of the Long Range Planning Committee. The report of the Sub-Committee was presented to the AIME Board of Directors at its last meeting on June 20-21 in New York.

In their report, the Sub-Committee made this statement with reference to the Long Range Planning Committee Report:

> *"Careful analysis of the Long Range Plan as it affects the inadequacies of certain phases in the present administrative organization of the Institute, has emphasized the merit of The Plan. The Study Committee believes that The Plan can do nothing but strengthen the Institute, because the study shows that the basic philosophy of The Plan was to set up the organization of the Branches on such a basis, so that more careful planning and execution of programs could be effected. The mere fact that the Branches have been dignified by calling them Societies in no way creates three little AIME's within the confines of the major AIME, as some uninformed critics might believe."*

After a very extended discussion, the Board voted to authorize any of the three branches to become a society once they submitted a set of bylaws acceptable to their membership and approved by the Board of the AIME. This action of the Board leaves each branch free to take the action it chooses. In voting the approval for conversion from branches to societies, the Board stipulated that it is not mandatory that a Branch become a Society and that it is not mandatory that each Division as now constituted remain in a particular Society. It is up to each Branch to carry forward the action of its own choice.

It was the consensus of the Board that before further action should be taken on the Long Range Planning Committee it would be advisable to make a study of the Institute Bylaws. The Board voted that a Committee be appointed to study and recommend changes or revisions in the Bylaws. This Committee was appointed and instructed to report at the next Board meeting.

It is no small credit to the vision of the AIME founders that the present major purposes of the Institute are essentially those they adopted Under these purposes the Institute has built, added to, and conserved a tremendous heritage of engineering knowledge. It has built, added to, and conserved an equally important legacy of professional concepts. The Institute could never have accomplished these purposes with a policy of standing still. Its guiding principle has always been one of seeking new and better ways to convert our riches of mineral resources and technical knowledge to the use of mankind. Your President hopes that a form of organization will be developed, as a result of the work of these committees and the interest shown by individual members, that will be more effective in carrying out the principles and purposes of the Institute. In order for the AIME to continue to be a great professional society and to adequately serve its members, the officers and Board of Directors must have the interest, counsel, loyalty, and active support of all the members.

C. E. Reistle, Jr.

Study Committee Report

AT the Feb. 21, 1956 AIME Board of Directors' meeting, a committee was appointed by President Reistle to study and to work out some of the organizational details and modifications that would be required to implement the Long-Range Plan authored by Andrew Fletcher, Leo F. Reinartz, and Carl E. Reistle, Jr. Specifically, "The Committee was charged to work with the Branches and the members of the Institute to implement the Long-Range Planning Committee's recommendations in the reorganization of the Institute and to report at the June Board Meeting."*

* From the Minutes of the Meeting of the Board of Directors, AIME, Feb. 21, 1956.

During the past four months the committee has had personal contact, cutting a wide geographical and technical cross section of interests, as well as considerable correspondence with many members of the Institute, in order to bring together creative and constructive ideas on the assignment.

Careful analysis of the Long-Range Plan as it affects the inadequacies of certain phases in the present administrative organization of the Institute, has emphasized the merit of the Plan. The Study Committee believes that the Plan can do nothing but strengthen the Institute, because the study shows that the basic philosophy of the Plan was to set up the organization of the Branches on such a basis, so that more careful planning and execution of programs could be effected. The mere fact that the Branches have been dignified by calling them Societies in no way creates three little AIME's within the confines of the major AIME, as some uniformed critics might believe.

The Plan provides for more uniformity in the Branch structure so that equivalent authority and responsibility can be exercised by the three Branches. The committee finds that at the present time the Petroleum Branch is fairly well coordinated and able to rationalize its problems. This holds true also for the Metals Branch to a degree, but the Mining Branch structure as defined by the Mining Branch Council bylaws is inadequate to cope with policy matters that arise. The professional divisions of the Mining Branch function as independent entities or six little AIME's within the AIME, and perhaps because of necessity, have had to assume nontechnical administrative responsibilities—some at variance one with the other. The admixture of administrative with professional responsibility, together with a certain degree of autonomy, has led to confusion and has inhibited progress because of indirection. This indirection by the Mining Branch is one of the major weaknesses of the AIME. To give direction where indirection exists in the largest Branch of AIME, can only strengthen the Institute as a whole.

It is of interest to note that the Plan is so logical in structure that many of the recommendations have already been implemented by common consent of the membership. These items will be discussed later on in this report.

Whenever the Plan is completely implemented, the committee believes that neither the Local Sections nor the Technical divisions will be aware of any changes so far as their autonomy and structure within their technical fields is concerned. However, improvement in overall administration and coordination of professional interests will be felt at the Branch level which will redound to the benefit of the Institute as a whole.

Following is a report of the progress of the committee to date, with quotations (in fine type) from the original Long Range Plan:

1. Name

The name should be *American Institute of Mining, Metallurgical, and Petroleum Engineers.*

a) This item **has been implemented.** The name of the Institute has been changed to *American Institute of Mining, Metallurgical and Petroleum Engineers.*

The abbreviation of *AIME* should be retained.

b) This item **has been implemented.** The abbreviation of *AIME* has been retained.

The symbol should be redesigned by including in the background a drilling derrick or some other item that is representative of the petroleum members.

c) This item **has been implemented.** The symbol has been redesigned and the new symbol is being used on the Institute letterhead and by the technical journals. This symbol includes the drilling derrick.

2. Branches

The subdivision of the membership groups should no longer be known as Branches but as Societies, and under the following titles:
Mining Engineering Society of the AIME
Metallurgical Engineering Society of the AIME
Petroleum Engineering Society of the AIME

a) The Mining Branch and the Petroleum Branch Councils are favorably inclined to the names, *Society of Mining Engineers* and *Society of Petroleum Engineers*, respectively. The Metals Branch prefers the name, *Metallurgical Society of the AIME*. It is recommended that section 2a **be implemented,** with these changes, upon approval of the Society bylaws.

Each society should form its own committee on education and on economics, in accordance with its own need. These committees would then be coordinated by an AIME council, or professional division, that would have a representative on the AIME Board of Directors. This Council would cover all three Societies in the Institute, and all AIME members could participate in it, as well as belong to their own Society.

b) It has been resolved by this committee that the activities of *MIED* and *MED* are of overall Institute interest and that they are certainly not peculiar to any one of the Societies. This suggests that these two groups function in their all-Institute capacity and be responsible to the AIME Board and not to the governing bodies of the Societies. Several of the Technical Divisions in the Branches already have education and economics committees. Wherever the need is felt for these committees, they should continue to function, but conversely, no pressure need be applied to other Divisions to form such committees until a need is recognized. It is believed that these existing divisional committees should be coordinated with the existing *MIED* and *MED* and that each of the two Institute-wide Divisions be represented to the AIME Board by a contact director to be appointed by the AIME President, and to be appointed from the 21-man "working Board." It is further recommended that the two groups be designated as Divisions rather than as Councils, to avoid confusion with the Executive Council of the Societies. It is suggested that the title of Board of Directors be reserved for the AIME Board and that the governing body of the Societies be designated as the *Executive Council.*

Subject to the approval of the AIME Board, each Society should organize its own Executive Committee, with officers and bylaws.

c) This section **will be implemented** upon approval of the new Society bylaws; however, section 2c should be expanded to include the sentence, "Alterations in the bylaws of the Societies must be approved by the AIME Board of Directors."

3. Directors

The number of AIME Directors should be reduced to 21, and the honor and responsibility of office be increased.

a) This section **will be implemented** upon approval of the new Society bylaws and will require a revision of the AIME bylaws.

The President, President-Elect, and Past-President should serve as Directors. Each society should have its own Nominating Committee for the election of its Directors, and six additional Directors from each Society should serve as Board members.

In the first year of reorganization, two Directors would be elected for three years, two for two years, and two for one year; thereafter, two would be elected each year by each Society for three-year terms.

b) This section **will be implemented** upon approval of the new Society bylaws and will require a revision of the AIME bylaws.

Transportation, but not food or housing expense, of any Director to the four quarterly Board meetings, should be paid by the AIME.

c) The committee **prefers** the wording suggested by the Inter-Branch Council recommendations on Long Range Planning as published in the agenda for the meeting of the Board of Directors, AIME, June 20, 1956.

Transportation, but not food or housing expenses,

(Continued on page 801)

(Continued from page 799)

when requested by the Society which the director represents and approved by the Executive Committee of AIME, shall be paid by the AIME.

However, the **implementation** of this section **will depend** upon a revision of the AIME bylaws.

The duties of the Board should be to establish the broad policies of the AIME, to maintain and protect the integrity and professional standing of the members, to plan and be responsible for the Annual Meeting, to handle the joint finances of the various groups, and to review and approve the recommendations of the President for membership on the standing committees. The Board should also have the power to approve or disapprove any changes in the organizational set-up or financial policies of the individual Societies.

d) The recommendation stated here is a **reiteration of the present policy** and is recognized to be beyond the scope of the Societies. The proposed bylaws of the three Societies recognize the sovereignty of the AIME.

4. President

Each society should name the President every third year. The Nominating Committee of the individual society from whom the President is to be elected should make the nomination for that particular year.

a) This section **will be implemented** upon approval of the new Society bylaws and will require revision of the AIME bylaws.

The President's transportation, but not food or housing expense, should be paid by AIME with an upset limit to be determined annually by the Board.

b) The committee **recommends** that for the sake of consistency with Item 3c that section 4b be reworded.

> The President's transportation, but not food or housing expense, when requested by the Executive Council of the Society he represents, and approved by the Executive Committee of AIME, shall be paid by the AIME.

5. Sections

As sections over the coming years will be influenced more by professional than by geographical lines, each Society should be given authorization to set up its own geographical areas and organize sections to meet its requirements. Until changed by the Board, the minimum requirement for the setting up of any section should continue to be 25 members.

Local sections can and should be flexible in their organization and operation. Some may be organized on a geographical basis, and some on a professional basis. It was not the intent of the Long Range Planning Committee to force a reorganization of local sections, but to let each section have the freedom to organize according to the needs and wishes of its membership. The Council of Section Delegates may be continued as an all-Institute organization, with its functions changed somewhat and some organization of section delegates on a society basis.

a) The responsibility for the organization of new Local Sections and for the promotion of the welfare of the Local Sections is recognized as being an All-Institute function of the utmost importance. Hence, this responsibility goes beyond the scope of the individual Societies. **It is recommended** that the President of AIME appoint a committee of three from the AIME Board of Directors to be called the *Committee on Section Affairs.* This committee should include one member from each of the three Societies. For the sake of continuity each member of this committee should have a tenure of three years. To establish a system of rotation, for the first year a member from one of the Societies should be appointed for a one-year term, a member from the second Society for a two-year term, and a third member from the third society for a three-year term. Thereafter one member would be appointed each year as a replacement. Senior member in service on committee would act as chairman.

6. Council of Section Delegates

As the Council has many desirable features, the Committee recommends that each society should set up its own Council of Section Delegates, whose primary responsibility should be to keep the Directors of that particular society informed. If, however, a society does not desire to have its own Council of Section Delegates, it will be under no obligation to do so. The society should pay the expenses of its own Council.

a) From considerable discussion and correspondence the committee **has resolved** that the activities of the Council of Section Delegates are of overall Institute interest rather than specific Society interest. To quote Mr. Reinartz:

> This Council was originally set up to give the Board of Directors of AIME grass roots' ideas and opinions with reference to Institute operations and policy as well as to receive information from the Board of Directors with reference to Institute policies and activities.

The committee **recommends** that the Council of Section Delegates be responsible to the AIME Board of Directors and that they be represented to the Board through the Committee on Section Affairs. By common consent of the chairmen of the three Branches, the new bylaws of the Societies do not provide for a Council of Section Delegates on the Society level.

It **is recommended** that the members of the Committee on Section Affairs be ex-officio members of the Executive Committee of the Council of Section Delegates and that this committee of three AIME directors function as the contact between the Council of Section Delegates and the AIME Board of Directors. It **is also recommended** that the Council of Section Delegates be recognized in the revised AIME bylaws and that the responsibilities of the Council be defined.

Regarding the expenses of the members of the Council of Section Delegates, the committee **recommends** that the policy here be consistent with that stated in section 3c and in section 4b. That is:

> Transportation, but not food or housing expenses for the delegates, when requested by the Chairman of the Local Section represented by the delegate, and approved by the Executive Committee of AIME, shall be paid by the AIME.

7. Initiation Fees and Dues

The Committee recommends that for the next three-year period initiation fees should be reduced from \$20 to \$10, and the respective Society be refunded the \$10.

a) After a review of the Institute budget the committee concludes that, as desirable as it may seem to be, **implementation** of section 7a **is impossible** at the present time.

The Committee believes that the dues for all three societies should be the same, and that for the time being at least, the \$20 fee should be retained.

b) This section **defines** the dues as they exist today.

The Committee recommends that the refund of 50 cents a member should be continued, but that for the next three years, while the suggested reorganization is taking place, the refund should not be any greater.

c) This section **defines** the policy of refunds to the Local Sections as it exists today.

The AIME Board should have the right to reduce or increase the initiation fees, dues, or rebates any time upon a majority vote of the Board members.

d) This section **is beyond the scope** of the bylaws of the new Societies but states the policy as it exists today.

8. Finances

Each society should have full responsibility for operating at a profit as shown by the AIME books. After expenses have been met, each society should have authority to spend all surplus funds after 25 percent of such surplus funds have been set aside for the interests of the AIME as a whole.

a) This section **will be implemented** upon approval of the new Society bylaws and a revision of AIME bylaws.

9. Bylaws

The AIME By-laws should be rewritten and simplified.

a) The committee **recommends** that immediate steps be taken to rewrite the AIME bylaws in accordance with the philosophy of the Long-Range Plan and with the modifications suggested in this report.

10. Meetings

The Committee recommends to the Board that a decided change should be made in the Annual Meeting program. For example, the number of technical sessions should be reduced, one or more joint sessions of the three societies be organized, and luncheon meetings be addressed by outstanding speakers on timely subjects of a general nature.

All business should be divorced from the Annual Banquet and only top awards should be given at that time. The other awards should be given at society or regional dinners or meetings, which it is believed will be strengthened by the transfer to them of some of the technical sessions.

The President should make his report on *State of The Institute* at an afternoon session during the Annual Meeting.

a) The whole of Section 10 **is being implemented** this year at the meeting in New Orleans. The committee and its correspondents are practically unanimous in agreement with this philosophy.

In conclusion, this committee **recommends** that the committee charged with the revision of the AIME bylaws review also the new Society bylaws for uniformity or consistency in the scope and structure of the three Societies.

STUDY COMMITTEE FOR IMPLEMENTATION OF THE LONG RANGE PLAN

A. Thornton—Metals Branch
T. Frick—Petroleum Branch
Will Mitchell, Jr., Chairman—Mining Branch

A. M. Gaudin,

R. Schuhmann, Jr.

J. Dasher

Extraction Process For South African Gold-Uranium Ores

OCCURRENCES of South African uranium have been known qualitatively for over twenty years, but no account was taken of them because of their low grade. In 1945, known uranium deposits were few, but their grades were 20 to 100 times higher than South African ores. Viewed in this light, the exploitation of South Africa's uranium is revolutionary indeed.

Development of various analytical procedures capable of dealing with the needs of the project accounted for one-half of the cost and included: a) simple and automatic radiometric analytical procedures, b) sampling procedures appropriate to prevent sample contamination, c) procedures for sample and record-storing to accommodate many thousands of analyses per month, d) chemical methods giving high accuracy analyses for high grade samples not at radioactive equilibrium, and e) development of rapid procedures having moderate accuracy for low grade samples i.e., mill tailings and barren liquors. This task is continuing today with major improvements coming from time to time.

Early Experiments

Preliminary fractionating experiments with the high grade ore showed that uranium is found in both a high and a low gravity fraction, Table I. The principal uranium mineral is uraninite, or pitchblende, which may occur in particles of 20 microns or larger, but generally is found in much greater subdivision, down to submicron size. Despersed in a hydrocarbon mineral called thucholite, gold is often intimately associated. Uraninite also occurs in association with sulfide minerals, particularly pyrite, and high-gravity fractions are high both in gold and uranium. The principal gangue mineral is quartz, but foliated silicates (micas and chlorites) are also present.

A. M. GAUDIN is Richards Professor of Mineral Engineering, Massachusetts Institute of Technology, Cambridge Mass.; R. SCHUHMANN, JR., is Professor of Metallurgical Engineering, Purdue University, Lafayette, Ind.; and J. DASHER is Process Research Supervisor, Crucible Steel Co., Pittsburgh, Pa. Paper was presented at the AIME Annual Meeting in New York, February, 1956.

It was at first thought that the ore should be concentrated by bulk flotation for gold and uranium and then leached for the two metals in succession. Various reagents were tested, and the most satisfactory proved to be oleic acid—1 to 2.5 lb per ton—used in a substantially neutral pulp, with an auxiliary collector for sulfides, and a frother. Softened water was required for good results. It was found that oleic acid could be replaced by cheaper carboxylic reagents available in Africa.

It was concluded that gold recovery by flotation followed by cyaniding would equal or exceed recovery by direct cyanidation, and uranium recovery would range from 80 to 90 pct, depending upon the grade of concentrate sought. A ratio of concentration of five or six was generally attainable. Table II gives representative data.

The second step was leaching of the flotation concentrate with sulfuric acid. Selection was made on the basis of its low cost and because the pyrite in the ore could be made into a source for the acid. Leaching proved erratic until it was discovered that an oxidizing agent should be added in adequate quantity to insure the uranium being made hexavalent. In addition, variation in the amount of metallic iron from crushing and grinding equipment, and in the amount of pyrite and its state of oxidation caused the erratic character of early tests. However, under favorable conditions, acceptable leaching results finally were obtained. Table III gives results of an early test.

Operation of the acid leaching process obviously requires a cheap supply of large quantities of sulfuric acid; fortunately, the ore contains enough pyrite to make sufficient acid. Experiments were made to ascertain the recoverability of the pyrite by flotation. It was found that the acid-leached residue was easily floated with good sulfur recovery and that small amounts of additional gold and uranium were recovered.

For new operations, flotation followed by acid leaching and cyanidation seemed more advantageous than cyanidation followed by acid leaching of the cyanidation tailings. For existing installations, the opposite was true, since gold was and is the main

product of the South African mining industry. Operators of existing gold plants preferred the idea of by-product uranium operation that did not affect gold extraction. Since any increase in uranium price would favor the all-leaching process, it was decided to direct investigation toward development of a continuous leaching process in which uranium was extracted from residues of gold cyanidation.

The attractive alternative of floating the cyanidation residue and then acid-leaching the flotation concentrate failed to give satisfactory results. This was due to the use of lime for protective alkalinity in cyanidation, giving rise to unintentional calcium activation of quartz during the uranium float with carboxylic acids.

Development of Uranium Dissolving Step

It developed that only two conditions were required for uranium dissolution: 1) that pH be lower than 2 at the end of the leach, and 2) that enough oxidizing agent be added to place the uranium in the hexavalent state. Uraninite is UO_2, with uranium tetravalent; pitchblende reputedly U_3O_8, has part of the uranium tetravalent and part hexavalent. Unfortunately, Rand uranium is primarily UO_2, and it is associated with reducing agents such as pyrite, oxidation products from pyrite, hydrocarbon, and metallic iron from grinding equipment, all of which consume oxidizing agent. However, pyrite remained in the residue and did not have to be fully oxidized. Extent of hydrocarbon oxidation was not ascertained, but thucholite was in the leach residues, even though the latter were depleted in uranium; so, it was assumed that little hydrocarbon was destroyed and that slowness of high uranium recovery may have been due to the time required for leaching liquor to diffuse through the tight cracks in the hydrocarbon to the uraninite.

Table I. Weights and Assays According to Sp. G. in the 150 to 200 Mesh Fraction of a Wet Ground Sample

Sp. Gr. Fraction	Wt Pct	U_3O_8 Assay, Pct	Uranium Distribution, Pct
Over 3.3	3.8	1.92	29.5
2.96 to 3.3	2.2	1.01	8.9
2.70 to 2.96	11.8	0.221	10.5
2.60 to 2.70	73.6	0.024	7.1
2.26 to 2.60	7.4	0.145	4.3
Under 2.26	1.2	8.60	39.7

Table II. Result Obtained by Flotation* of Freshly Ground Pulp

	Wt Pct	Distribution	
		U Pct	Au Pct
Cleaner concentrate	14.4	81.3	98.8
Rougher tailing	85.6	18.7	1.2

* Locked-batch testing, the cleaner tailing from each test being added to the feed to the next.
Reagents were as follows:
Oleic acid, 2.5 lb, (added to grind).
Sulfuric acid, 0.1 lb, to pH 7.5 (added to first conditioning).
Amyl xanthate, 0.025 lb, (added to second conditioning).
Pine oil, 0.04 lb, (added to third conditioning).

Table III. Ambient-Temperature Dissolution of Uranium from Flotation Concentrate

H_2SO_4, lb per ton of concentrate	60	40	60
$Fe_2(SO_4)_3$, lb per ton of concentrate	30	20	0
pH of pregnant liquor	1.35	1.55	1.40
Residue assay, U_3O_8, pct	0.019	0.027	0.030
Extraction of U_3O_8, pct	83.9	77.6	75.9

Among the best oxidizing agents were dissolved ferric iron and solid manganese dioxide. Manganese dioxide turned out to be the preferred agent on a cost basis, and also because it did not load up the system with iron salts which became troublesome at a later stage. However, all leach liquors contained considerable iron in solution. This arose in part from pyrite, in part from metallic iron, and in part from foliated silicates. The iron was in both ferrous and ferric form, and the manganese had become dissolved to manganous ion. It is likely that manganese dioxide is the primary oxidizing agent and iron acts as a catalyst. Ferrous iron becomes oxidized to ferric at a manganese dioxide surface. The resulting ferric iron then oxidizes solid uranium oxide, thereby becoming reduced again to ferrous iron.

Another function which iron may perform is that of tying up phosphate ions in the leach liquors by forming complexes or precipitates, and thus reducing loss of already dissolved uranium by premature precipitation.

Recognition of the critical importance of maintaining suitable oxidizing power in the leaching solutions led to using a calomel half-cell in series with a platinum electrode in the leach liquor. It was found empirically that at negative potentials more than —400 mv, the uranium is entirely hexavalent. The redox potential for the $U^{4+} \rightarrow UO_2^{2+}$ couple is approximately 330 mv, and at —300 mv the iron is all ferrous and at —600 mv it is all ferric. To get good dissolution, some ferric iron must be in the liquor. Solution potentials of —450 to —500 mv were found suitable.

The requirement for substantial terminal acidity suggests two objections to simple leaching. Much free acid remains unutilized in the leach liquor, and many desired constituents have been dissolved, increasing the difficulty of purifying the pregnant solution. Study was made of the simple leaching flowsheet, of a two-step leach with neutralizations to pH 3.5 before solid-liquid separation, and of a two-step countercurrent leach with terminal pH 3.5. The second provides liquor purification without acid economy, and the third provides both at the cost of an extra step of solid-liquid separation. A variant of the simple leach flowsheet was eventually selected because it avoided the extra step.

Separation of Residue from Pregnant Liquor

In view of the wide experience in South Africa with the cyanidation process, no great difficulties were expected in the separation of residue from pregnant liquor. Based on an assumed identity of behavior for the lime-flocculated pulps in cyanidation and the acid pulps from the uranium leach, either a filtering or a counter-current decantation operation appeared sufficient. However, pulps with a pH near 2 are dispersed and not readily flocculated by lime or other saline compounds. Eventually, animal glue was found effective.

Solid-liquid separation in a cyclic process gave more trouble than in a simple leach. It is probable that this was partially due to increased ionic strength of the cyclic liquors, and the difficulty was noted both in counter-current decantation and filtration.

Bench scale pilot plant tests of both separation methods indicated the problems involved. It was estimated that about three times the filtering area per filtration step would be required in uranium leaching as in cyanidation. Furthermore, difficulties

Table IV. Uranium Leach Liquor Obtained from Cyanidation Residue

Component	Assay, Gpl
U_3O_8	0.20
Fe^{++}	2.20
Fe^{+++}	1.50
Al_2O_3	2.50
SiO_2	1.00
P_2O_5	0.09
Ca^{++}	0.70

Hydroxide Precipitate Obtained From Pregnant Liquor

Component	Assay, Pct
U_3O_8	2.5
Fe_2O_3	28.8
SiO_2	10.5
MgO	9.0
Al_2O_3	18.5
Loss on ignition	30.8

Table V. Data for Continuous Application of Anion Exchange Resin to Uranium Extraction

	pH	U_3O_8, Gpl	Fe, Gpl
Pregnant solution	1.1	0.272	11.7
Barren solution	1.1	0.004	11.8
Eluate	1.2	0.532	0.14

Precipitate*	
U_3O_8, pct	54.3
Fe, pct	14.24
Al_2O_3, pct	1.7

* Obtained by passing ammonia to excess through the eluate, filtering, and drying the precipitate.

were encountered in washing the cake by displacement, the rate of wash passage being slow. This led to the choice of double filtration with an intermediate stage of repulping.[1] This was advantageous because filtration is widely used for solid-liquid separation in cyanidation, and also because filtration yields more concentrated pregnant solution.

Extraction of Uranium from Pregnant Liquor

By Precipitation: Since uranium hydroxides are insoluble, the first approach to the extraction problem was by use of a precipitant, and strong alkalis were investigated at the outset. It was found that uranium-free barren liquors could be obtained through the use of any carbonate-free alkali, such as NaOH, NH_4OH, CaO, or MgO; however, the character of the precipitates differed. Magnesia produced a granular precipitate which was decidely the best of the lot, but several kinds of magnesia were tested, and it was found that they did not all behave alike. Those formed by calcination of magnesium carbonate at relatively high temperature were less reactive. On the other hand, magnesia precipitated from sea water by reaction with lime was very fine grained and highly suitable for precipitating uranium. In addition, it is easy to ship, and weight for weight, the most concentrated alkali.

Unfortunately, all alkali precipitations waste the acid in the pregnant liquor and the acid represented by metal salts other than uranium in solution. The grade of the products is low, and many impurities are carried to the refining stage. This is suggested by a pregnant liquor analysis and is confirmed by analysis of a magnesia precipitate, Table IV.

Selective uranium precipitation with alkali is theoretically possible, since the solubility products of the several metal hydroxides vary over a wide range. The metals primarily involved are uranium, ferrous and ferric iron, aluminum, and manganese. Iron caused much trouble because of its abundance, and because it occurs in two valencies. This can be eliminated by first oxidizing all the iron with additional manganese dioxide. On gradual addition of magnesia, iron first precipitates up to pH 3.5 as a mixture of oxide and basic sulfate. A second precipitate carries the aluminum, silica, and uranium precipitate, AlSiU, and manganese comes down as manganous hydroxide above pH 6.5. The *crop* precipitate is thus obtained between pH 3.5 and 6.5. This is appreciably cleaner than precipitate obtained without excluding the iron, but it is still such a low grade—usually 4 to 6 pct U_3O_8—as to require extensive processing. Carbonate leaching is effective but puts an extra step in an already complex procedure. Special precautions must be taken if selective precipitation with alkalis is to be successful, because low-temperature ferric hydroxide precipitates are notoriously prone to carry adsorbed impurities from their liquid environment. Boiling the iron precipitate made it easier to filter and removed much of the adsorbed uranium. When this boiling step was included, the loss of dissolved uranium in ferric hydroxide precipitate was held well under 1 pct.

Manganese precipitation was proposed as a device to insure against uranium losses and to provide a means for regenerating the manganese dioxide. The manganese precipitate can be oxidized with atmospheric oxygen in alkaline pulp by prolonged agitation with air at ambient temperature in a Pachuca tank.

Since uranium is less soluble in tetravalent form, much attention was given to reduction of the pregnant liquor preparatory to precipitation. Reduction can be obtained with such metals as aluminum, zinc, iron, or sodium amalgam, and although laboratory reductions can be made to go to the U^{3+} stage, the most that can be expected in practice is substantially complete conversion to U^{4+}.

If the pH is high enough during reduction, uranous oxide or hydroxide can be expected to precipitate, and if the concentration of orthophosphate, pyrophosphate, or arsenate is sufficient, the uranous salt can be expected to precipitate during reduction. Actually a sort of cementation precipitate was obtained by certain variants of the reduction procedure, and in some cases it was necessary to add the precipitant after the reduction. The best precipitant seemed to be pyrophosphate, but it had to be added in carefully gaged amounts to prevent complexing of uranous uranium. While not as effective a precipitant, orthophosphate offered less risk of loss by complexing.

In a laboratory experiment, 19 liters of leach liquor assaying 79 mg U_3O_8 per liter were brought to pH 1.3, then agitated with 5 gm of iron powder and 3 gm of sodium phosphate to produce the uranous pyrophosphate precipitate. After filtration, this precipitate was treated as a slurry with 10 gm of sodium hydroxide and filtered again. The final concentrate contained 67.7 pct U_3O_8 for 89.9 recovery. Further experiments improved the uranium extraction to the range above 95 pct. If pH during reduction was not low enough, a major part of the uranium remained with the iron or other reductant.

The pseudo-concentration with copper, iron, or aluminum has many attractive features: the pregnant solution can be made to flow through a column of the cementing metal, and there is practically no

problem in separating the desired product from the barren liquor.

By Ion Exchange: The suggestion was made that ion-exchange resins could be used to extract the metal. Experiments to fix uranium-bearing cations with cation-exchange resins were disappointing, because of the non-selectiveness of the resins. Iron, manganese, calcium, magnesium, and aluminum were extracted about as well as uranium. The advantages of cation-exchange resins were so questionable that the project was dropped.

Research at the Battelle Memorial Institute led to the discovery that uranium could be extracted selectively from sulfuric acid solutions containing relatively large quantities of iron and aluminum, by using anion-exchange resins. Application of anion exchange resins to extraction of Rand leach liquors was so promising that development of other methods of uranium extraction was suspended.

It is well known that uranium is very tenaciously attached to oxygen. Hexavalent uranium in fact occurs as the divalent uranyl ion UO_2^{++} rather than as U^{6+}. Uranium also forms many double salts, as with sodium and calcium, which are termed uranates and in which the grouping UO_4^{--} seems to prevail. It was thought that the results with anion exchange resins were due to adsorption of UO_4^{--} or $[UO_2(OH)_4]^{--}$ by the resin. But this could not be the case, due to the high acidity, hence low $[OH^-]$, at which the successful extraction was carried out. If such a complex hydroxylated ion as $[UO_2(OH)_4]^{--}$ does exist, its abundance must depend on the fourth power of $[OH^-]$. A change from say pH 3 to pH 1 should reduce its concentration by 10^8 and make a huge difference in the behavior of the resin. This does not occur, even though there is a slight pH effect on the resin extraction.

A study was undertaken to find out if a sulfate complex was involved. Some leaches were carried out with acids other than sulfuric, which greatly reduced sulfate-ion and bisulfate-ion concentrations in the leach liquors. Also, some artificial liquors were made and tested, in which various acid radicals were added, and a careful chemical study of the system was made. It was shown that the resin adsorbs at least four important anions: HSO_4^-, $SO_4^=$, $UO_2(SO_4)_2^=$, and $UO_2(SO_4)_3^{4-}$. Of the two uranium-bearing anions, the latter is abundantly adsorbed.

Extraction of uranium from clarified leach liquor involves two major steps: the *adsorption* step during which the resin is picking up uranium from solution, and the *elution* step during which the resin gives up its uranium to the eluant solution. The solution obtained by this elution step is the *eluate*. During the adsorption step, a stream of pregnant solution passes through a column of resin particles at a sufficiently slow rate to permit the adsorbable ions to diffuse into the resin, while the exchanged ions diffuse out. The exchanged ions, which may be chloride, nitrate, bisulfate, or sulfate, are then found in the *effluent* liquor in stoichiometric equivalence to the adsorbed anions. Of course, uranium in the pregnant liquor is not all in the complex forms, since kinetic equilibrium must exist between the various forms in which dissolved uranium occurs.

At the beginning of a test the effluent is very low in uranium—generally well under 0.1 ppm from a feed liquor of about 100 ppm. As the resin becomes saturated, the effluent retains increasing quantities of uranium, reaching the concentration of the pregnant liquor when the resin is fully loaded.

The fully loaded resin is then treated with the *eluant*, which removes the uranium, replacing it by the ion the uranium had displaced during the adsorption cycle. This is obtained by providing the eluting liquor with a totally different regime of ion concentrations than the feed liquor. The eluate (the product of the second step) is a solution of uranium in acidulated water. Uranium concentration is several times as large as the feed, and the impurity content is much reduced. Table V shows results that may be obtained. The uranium grade of the eluate is twice that of the pregnant solution, and in recent work, eluates have been much higher in uranium, representing a concentration ratio of 10:1 to 20:1. Iron is reduced about 100 fold, and the reduction in aluminum and manganese is generally more drastic.

By selecting certain cuts in the eluate, it is possible to obtain a higher uranium content and greater purity. Recovery of the metal as oxide is obtainable by ammonia precipitation from the eluate, filtration, and calcining.

Because the ionic population of a bit of resin in a column is constantly changing with time, the process of ion exchange is fundamentally a batch operation. For engineering reasons, it is easier to manage the process on a multiple-batch basis than continuous operation, although progress in this direction is being made.

Use of ion exchange resins for extraction of metal from hydro-metallurgy operations was entirely new to extractive metallurgy, and some misgivings were entertained about its engineering application. Problems were anticipated in channeling in columns, plugging of columns, poisioning of resins, mechanical wearing of resins, controlling the process, etc. Fortunately, there existed considerable engineering experience in water treatment, sugar refining, and the food industries to help in column design. Pilot plants were constructed here and in South Africa to explore the engineering aspects of the ion-exchange process.

An automatic resin life tester was developed to evaluate the decay in quality and performance of the resin and the loss of resin over long periods. It was found that little loss in resin weight occurred and that the particle size of the resin showed no great change after long use. Some unexpected results regarding the poisoning of resin and its rejuvenation were obtained. The loading of the resin may be described by curves plotting uranium content of effluent liquor as a function of the volume of liquor that has passed through the column. Loading curves obtained in practice with some ores differed from those obtained with pure uranium sulfate feed solution. This behavior suggests the preferential adsorption of a less abundant but more tenaciously adsorbed ion that contains no uranium. Study was begun to establish the identity of the poison. Certain sulfur-oxygen complex ions and the cobalticyanide complex ion were found to be the chief offenders. In different localities other poisons have been found, but on the Rand, the cobalticyanide ion proved to be the worst. It arises from prior treatment of the ores for gold and is generally present in minute quantity. The resin is such an excellent concentrating device for the ion that concentrations higher than 1 ppm can be troublesome. Special purging methods were sought and found to eliminate the poisons; the most effective have been dosages of sodium hydroxide, sodium

sulfide and ammonium thiocyanate. Additionally, it was found that it pays to water-wash the cyanidation tailings, as this removes much cobalticyanide and lessens the frequency of the purges.

The Complete Process

The complete process for gold and uranium recovery as finally developed includes:

1) Dry crushing the ore;
2) Wet grinding with size control;
3) Dewatering to 60 to 62 pct solids;
4) Cyanidation;
5) Filtration of the residue, with water washing of the residue;
6) Recovery of gold from the liquor in the usual way and recycling of barren;
7) Leaching of residue with sulfuric acid and manganese dioxide;
8) Filtration of the acid-leached residue followed by washing, and clarification of the pregnant uranium leach liquor;
9) Extraction of uranium from the pregnant liquor by anion-exchange resin columns;
10) Elution of the resin columns;
11) Ammonia precipitation of uranium from the leach liquor and filtration of precipitate;
12) Calcining of precipitate;
13) Flotation of the acid-leached residue for pyrite recovery;
14) Filtration of pyrite concentrate;
15) Roasting concentrate for production of sulfur dioxide; and
16) Conversion of sulfur dioxide to sulfuric acid.

The first six steps in this sequence represent the usual treatment of the ore for gold recovery, the next six steps recover the uranium, and the last four steps produce the main leaching agent.

The process is now successfully operating on a large scale and the industrial application will be described in forthcoming South African papers.

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Rutile—An Economic Study

by Ernest G. Enck

EXPANDING markets and technological investigations now in progress for commercial production of titanium metal and alloys, as well as expanding uses for the oxide, have resulted in greater production, increased prices, and accelerated search for additional commercial occurrences of titanium minerals.

For more than 50 years rutile has been used in moderate quantities in ceramics, in the production of ferrotitanium, as well as nonferrous titanium alloys. During the early 1930's, use of pure titanium dioxide was introduced as an ingredient of coatings for electric welding rods. For technical and economic reasons rutile was soon found to be as good or better for mild steel welding rods, and this use continues to account for a good share of the rutile sales in the U. S.

Today rutile is considered the standard raw material by most producers of titanium metal. It is safe to assume that rutile could continue to be the most desirable source of titanium in the future. Availability and price will be the controlling factors in establishing its future growth.

Africa: Rutile has been recovered from alluvial deposits in the French Cameroons, which reported a peak production of 3320 tons in 1944 with a declining tonnage each year thereafter until 1953, when reported production was 52 tons. It is believed that the deposits are of limited extent and mining operations are on a very primitive scale. Most of the production from this area found its way to France and England and has contributed very little to American needs.

ERNEST G. ENCK is Secretary and Director of Planning of the Foote Mineral Co., Philadelphia.

Several years ago considerable publicity was given to the sand deposit some 24 miles south of Durban at Umgababa in the Union of South Africa. It is said that reserves indicate some 100,000 tons of rutile, 2 million tons of ilmenite, and some zircon. The economics of such an operation would depend on the recovery of ilmenite as the main product. Tests indicate the ilmenite to contain only 50 pct TiO_2, which is too low to be considered as an exportable grade of concentrate. Until South Africa can support a large titanium pigment operation for local needs, utilizing this ilmenite, it appears very unlikely that this deposit will develop to produce rutile alone.

Australia: Extensive and rich beach sand deposits on the east coast of Australia in New South Wales and Queensland show a high percentage of recoverable heavy minerals. The first operation of any importance was at Byron Bay, New South Wales, in 1934. At the present time a number of operators produce rutile concentrates, and some small operators produce a mixed concentrate which in turn is sold to the larger plants for final separation. As the industry gains maturity, modern equipment is being installed to obtain better efficiency and reduce costs.

This cutterhead dredge is capable of digging 1200 tph to a depth of 45 ft below the water level at a Florida operation.

In 1955 Dunn and Morgan of the Bureau of Mineral Resources of Australia stated, "Available reserves of rutile on the east coast of Australia have recently been estimated at 700,000 tons in high grade deposits (more than 40 lb of rutile per cubic yard), and a minimum of 1.5 million tons in low grade deposits (approximately 20 lb of rutile per cubic yard)." These figures are considerably larger than previous estimates and provide a basis for planning many years of production.

Brazil: In the state of Goyaz in Brazil rutile is found in gravel and similar alluvial deposits and is recovered by native hand labor. The deposits are many hundreds of miles from public transportation so that movement of the ore must be undertaken by oxcart and burro. In the southern part of Goyaz and the adjoining state of Minas Gerais there are occurrences of an ilmenorutile. Reserves are small and the problem of upgrading the ilmenite-rutile mixture relegates this area to one of minor importance. In 1941 rutile production was begun in the arid northern state of Ceara. Workers with picks dug small pits and hand-sorted the clay and gravel, occasionally finding a piece of rutile. After a day's work the pickings were taken to a central point and washed to recover rutile crystals ranging from ¼ to 3½ in. diam. This primitive type of operation provided essential tonnages of rutile so sorely needed in the U. S. from 1941 to 1945. As prices dropped and demand lessened after the war, production of rutile disappeared in Brazil.

The rutile, monazite, ilmenite, and zircon beach deposits near Victoria, Brazil, contain substantial reserves of rutile. However, they have been mined sporadically and on a small-scale basis.

Mexico: In 1954 the Republic Steel Corp., Cleveland, Ohio, acquired large holdings at Oaxaca, Mexico. This area, long known for its rutile showings, is in relatively inaccessible country some 26 miles from the nearest shipping port, Puerto Angel. It is reported that the deposits have inferred reserves of millions of tons. Although active exploration continues, no published figures are available to confirm or deny the original estimate. To supply rutile from this area many millions of dollars will be required to construct docks, roads, mill, village, and other facilities always required when a mine is established in a remote area. Metallurgical studies are being carried out on the ore, and it is understood that acceptable concentrates have been produced. Because of the heavy capital investments required, a large yearly production will be necessary to amortize the investment. This may provide rutile at an attractive price so as to encourage its use for metal production. If the owners decide to proceed with commercial development, no production is expected before late 1957, if then.

United States: Virginia, Florida, and Arkansas have in the past been the producing areas of the U. S. Although slight production in South Carolina is reported, today only Florida accounts for domestic supply. Rutile occurs with other heavy minerals in many places in the Florida sands. The average heavy mineral content is reported to be 4 pct of the sands and consists primarily of rutile, ilmenite, zircon, staurolite, and traces of monazite. The two largest operations are at Starke River and Jacksonville. Essentially the same metallurgy is practiced at both these deposits for the recovery of the heavy minerals. The Jacksonville operation produces an ilmenite product, a rutile concentrate, as well as zircon. The Starke River operation does not attempt to separate the individual titanium minerals, but produces instead a concentrate consisting of ilmenite, rutile, and leucoxene. It is very unlikely that this latter deposit will ever be operated for recovery of a separate rutile product.

In Virginia and Arkansas rutile occurs in rock deposits. The famous Roseland, Va., deposit consists of ilmenite and rutile disseminated in a feldspar rock. This operation, begun in the early 1900's, is reported to have had a production capacity of several thousand tons per year of rutile when it was shut down in 1942. New milling and quarry facilities would have to be installed at this location if production of rutile were resumed. This appears unlikely in view of the limited reserves remaining in the deposit. It is reported that a new rutile mining operation will start soon near Montpelier, Va. The Arkansas deposit at Magnet Cove consists of a

complex mixture of igneous and sedimentary rocks. Much of the titanium is in the form of brookite, a type of rutile, along with some ilmenite. In the past, many attempts have been made to operate in this area for the recovery of brookite. Because of the small indicated reserves and complex metallurgy required to produce a satisfactory product, it is not expected that this area will provide much brookite in the future.

Production: As shown in Table I, Australia is the world's largest producer of rutile concentrates. It is likely that its present capacity will be enlarged to provide 60,000 tons in 1956, 70,000 tons in 1957, and 80,000 tons by 1960.

It is reasonable to speculate that production in the U. S. could double by 1960. Therefore, excluding possible production from Mexico and the marginal tonnages from Africa and Brazil, a world production of 95,000 to 100,000 tons can be expected by 1960.

Consumption: Despite increased demand in the U. S., production and imports were less than 40 pct of the 1955 world production as shown in Table II. Titanium metal production accounted for the increased demand.

World consumption, the U. S. excluded, can be gaged by reference to Table III, which lists Australian exports to various countries. The European market is substantial. Most of this market, however, is caused by the demand for rutile in the production of pigments and metal. A small portion goes into welding rods.

Prices: Australian producers have always sold their rutile on the basis of a long ton f.o.b. steamer, Australian port. In the early days the price was £A 32 (U. S. dollars, $71.00) per ton. In 1948-1950 the price dropped to £A 20 (U. S. dollars, $44.80) per ton. Inflation and increasing world demand resulted in rising prices: £A 50 (U. S. dollars, $120.00) in 1954, and £A 70 (U. S. dollars, $157.00) in 1955. These latter prices were for contracts, some of which extend into 1956-1958, with producers committing for at least 80 pct of their production. For the past six months prices for excess and marginal production and forward contracts beyond 1957 have been offered at prices between £A 100 (U. S. dollars, $224.00) to £A 150 (U. S. dollars, $336.00). These prices have created considerable unrest, especially in the U. S., and continued practice will discourage consideration of rutile for all large tonnage applications.

Future U. S. Demand, Tonnages, and Prices: The welding rod industry will continue to increase its requirements for rutile. By 1960 this could amount to 12,000 tons per year. Ceramics and alloys and carbides could require 6000 tons per year. The use of rutile admixed with ilmenite for pigment production could place increased demands on rutile in future years. All these uses could result in an annual requirement of 25,000 tons.

Each ton of titanium metal requires approximately 2 tons of rutile. It has been predicted that by 1957 metal production will be 30,000 tons and by 1960, 200,000 tons, or 60,000 and 400,000 tons rutile, respectively.

Present prices are not conducive to planning long range uses for rutile in large quantities. Unless rutile can eventually be delivered to eastern U. S. ports at $120 per short ton, equivalent to £A 50 per long ton (Australia), there will be increasing attention paid to utilizing ilmenite and slags, such as sorel slag, not only for metal production but also for welding and ceramics. It is predicted that such prices would develop a yearly market of 200,000 tons of rutile by 1960.

Conclusion

1) Present high prices of rutile are mainly caused by present demand for metal production.

2) If substantial production can be achieved by 1960 at reasonable prices, metal producers will continue using rutile as their chief raw material.

3) If prices remain high, metal producers and other consumers will find ways to use raw materials such as ilmenite and titanium slag, bringing about smaller demands for rutile than presently exist.

4) Therefore, high prices for rutile will not continue beyond 1958-1959, as tonnages consumed will depend on the ability to produce and the attitude towards pricing of present and future producers of this interesting mineral.

Acknowledgment

The author wishes to acknowledge the use of information and statistics published in the *Australian Mineral Industry Quarterly Review*, and statistics from the *Mineral Yearbooks* and other publications of the U. S. Bureau of Mines.

Table I. World Rutile Production, Net Tons

Year	Australia	U. S.	French Cameroons	Brazil	Others	Total
1940	1,810	2,890	440	550	1,200	6,890
1941	4,200	3,130	1,980	2,610	2,270	14,190
1942	6,050	2,645	2,640	5,080	2,610	19,025
1943	7,400	4,000	3,010	5,020	2,770	22,200
1944	9,730	6,920	3,660	1,720	1,940	23,990
1945	10,900	7,180	1,560	32	770	20,590
1946	9,120	7,450	1,390	6	360	18,352
1947	14,750	8,560	835	—	235	24,326
1948	16,890	7,380	640	—	140	25,050
1949	15,360	7,400	450	—	20	23,230
1950	19,780	7,535	28	—	75	27,418
1951	39,100	7,189	120	—	70	46,479
1952	42,500	7,125	325	—	210	50,150
1953	42,500	6,825	60	—	120	49,505
1954	49,200	7,411	—	—	—	56,611
1955	53,000*	8,400*	—	—	—	61,400*

* Estimated.

Table II. Use of Rutile in U. S., Net Tons

Year	1951	1952	1953	1954	1955
Welding	8,500	9,000	8,500	7,000	8,750*
Alloys and Carbide	3,000	3,500	4,000	5,000	4,500*
Metal & Misc.	2,300	2,500	5,400	7,500	9,500*
Ceramics	300	400	500	500	800*
Total	14,100	15,400	18,400	20,000	23,559*
World Production, pct	30.3	30.7	37.2	35.3	38.3

* Estimated.

Table III. Australian Exports of Rutile, Long Tons

Destination	1952	1953	1954
U. S.	18,392	13,416	14,418
United Kingdom	9,073	8,662	9,891
Netherlands	1,458	3,129	4,634
Federated Republic of Germany	1,032	1,914	3,926
France	2,730	1,880	3,439
Italy	894	1,769	2,044
Sweden	1,657	2,521	1,555
Belgium	640	465	1,356
Japan	93	3,128	1,223
Others	1,678	292	1,931
Total	37,654	37,176	44,417

Status of Mining Geophysics Today

by Walter E. Heinrichs, Jr.

Photographic Survey Corp. Ltd.

Magnetic • Gravity • Seismic • Electrical • Radioactive • Geochemical

BEFORE covering the separate methods used in mining geophysics, it may be well to mention some current basic geophysical prospecting concepts. As in most fields, a better understanding and means of studying these fundamentals usually provides the more common improvements, rather than new principles being discovered.

The relative detail and complexity of most mining geology often results in the use of geophysics in problems it cannot solve. On the other hand, suitable applications are often ignored or left unrecognized. To minimize this, it is important to consider geophysics as a phase, or additional tool, in geological or exploration engineering.

Of primary importance is the fact that most of the methods deal with specific earth physical properties. Secondly, in practice, these properties rarely relate directly or exclusively to ore. Usually the measurements result from an integrated effect of all related forces and material within range. Furthermore, the forces and material can seldom be described by such ideal terms as *linear, symmetrical,* or *homogeneous.* Thus the resultant data are more frequently relative rather than absolute.

Overall ability to obtain, discriminate, select, or localize an effect depends on the following.

1) Amount of physical-property contrast between the source and the surrounding rock.

2) Size and shape of source.

3) Mean distance of source from point of measurement.

4) Degree and type of interference.

5) Accuracy, sensitivity, and validity of measurements and related corrections.

Whether or not the source or effect is important depends on ability to evaluate and equate the factors and results in terms of significant geology.

WALTER E. HEINRICHS, JR. is Exploration Manager for Minerals Exploration Co., Tucson, Ariz.

Magnetic Method: The magnetometer is used essentially to localize zones of magnetic mineral concentration or the lack of such zones. Thus the only direct association is in connection with magnetic ores, or occasionally, with highly nonmagnetic mineralized zones surrounded by relatively magnetic host rock. Indirect associations are revealed by structural studies. Larger structures, and particularly basement features, sometimes respond because relatively large masses can give measurable effects even though relative magnetic differences are small.

Elevation and terrain effects are usually less than in most other methods. The effective working depth depends on the size, shape, and magnetic contrast between the source and surrounding material. Determination of depth to a particular source is sometimes possible; however, the results usually give only order of magnitude values. This is also the case for most of the other force-field methods such as gravity and electrical.

Equipment is available for all types of application and may be continuous recording or station-to-station reading. Costs vary from \$25 for a single oneman dip needle to more than \$25,000 for continuous recording instruments. Cost and speed of coverage will differ widely depending on type of equipment used. Aerial and mobile continuous traverse work costs between \$1 and \$15 per profile mile of coverage. Speed will vary from 10 to 250 profile miles per day. Portable ground work usually averages about 50 observations per day at approximately \$3 per observation. Average costs vary between extremely wide limits and depend on the type of coverage used and the scope and detail dictated by the survey problem. In a large reconnaissance survey, minimum costs might be as little as 10¢ per acre. For a small, accurate, and detailed survey, the cost might exceed \$100 per acre. An approximate overall thumb rule average for most mining geophysics is about \$10 per acre, per method.

Most recent improvements have been in continuous recording devices for air and mobile use. At least two companies are adapting similar equipment to be used pack fashion by one or two men on the ground. Several liquid-damped, torsional-nulling magnetometers promise to be cheaper, faster, and more rugged station instruments for portable use. Drillhole magnetometers are available but are still in an experimental stage.

Gravity Method: The gravity meter is used to delineate major structure and to localize areas of high density contrast such as large caverns or large bodies of very dense material. In some respects the method is similar to the magnetic method, but fewer geological ore correlations with measurable density contrasts are known. The method requires accurate elevation and terrain information and considerable computation, all of which decreases the overall speed of coverage and increases the cost.

Present instruments can be used underwater, underground, and on the surface but not continuously mobile or airborne. Gravity surveys in mining cost between $10 and $50 per observation with up to 60 observations per day. Available equipment is portable, accurate, rugged, and dependable. A good portable instrument costs about $8000 and can be operated by one man.

Seismic Method: Using travel-time measurement of refracted or reflected sound energy, generally from a small dynamite blast, the seismic procedure is the only system providing very deep penetration and accurate depth resolution. The method is costly, however, and can be used only in cases of simple geology with some known velocity and directional control. For this reason it has had limited application in mining. It is best suited for stratified geology, certain larger structural problems, or deep bedrock determinations over large areas.

Minimum equipment cost is $5000 and two operators are required. Equipment can be used underground and in drillholes on special problems. Cost data are highly variable. A usable figure might be ten depth determinations per day at $30 each.

Considerable improvement has been made recently in decreasing costs and increasing versatility and portability of equipment. High speed, shallow-reflection instruments are now available and further research and progress are anticipated.

Electrical Methods: This broad classification covers the numerous techniques which deal with certain electrical properties of the earth. It includes such methods as natural-potential, electromagnetic, resistivity, and pulsing.

Results from electrical work are affected by surface, terrain, water conditions, and certain natural and artificial interference. Response and resolution are dependent on accounting for or correcting these influences. Again, ability to discriminate between these factors and important zones of effect will depend on the size, shape, and distance of the source and the physical-property contrast between the source and the surrounding media.

Sometimes the source is very definite and directly due to ore or massive sulfide. More often it may be subeconomic mineralization, alteration, water table, undefinable structure, or a mixture of each.

Effective working depth varies from a few feet to 500 and possibly 1000 ft under ideal conditions. Some claims have been made for results below 2000 ft but these are considered doubtful.

Except in natural-potential work the electrical methods use man-made energy applied directly to the earth by electrodes or inductively by coils or cables. The energy may be in the form of direct, alternating, or pulsating current, or a combination. Frequency may be fixed or variable. Natural-potential results depend on active oxidation of a sulfide mass producing measurable current as in a battery.

Most of the procedures give data on single observations taken from station-to-station, on the surface, underground, or in drillholes. An important exception is electromagnetic work, one of the latest to take to the air. This helps decrease a serious lack in geophysical tools for rapid reconnaissance. Improvements have been made in the electronics which provide the fundamental means of measurement, power supply, and control in these techniques.

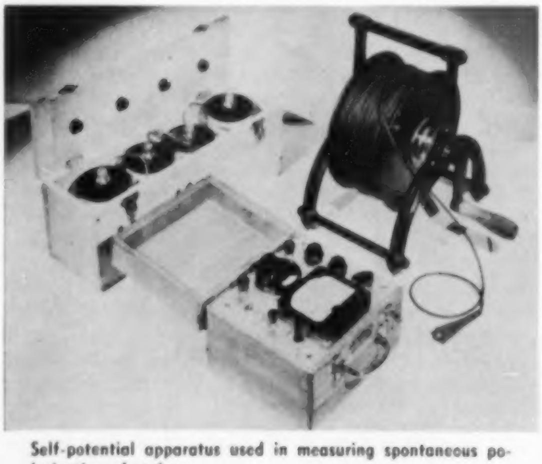
In terms of cost and production, natural-potential work and portable magnetic work are roughly equal. The same is true for aerial electromagnetic and aerial magnetic. Except for these examples, cost and production vary widely with type of equipment. The average would be about $15 per observation and 30 observations per day.

Radioactive Method: Publicity resulting from the world-wide uranium rush since 1948 has made this the universal geophysical method. Because of the short penetration of radioactive rays its major use, direct location of radioactive minerals, is restricted to very shallow working depths. A lesser known application is the mapping of broad-rock types under shallow alluvial cover and the location of major faults. It is also used for lithologic and assay correlation in drillholes.

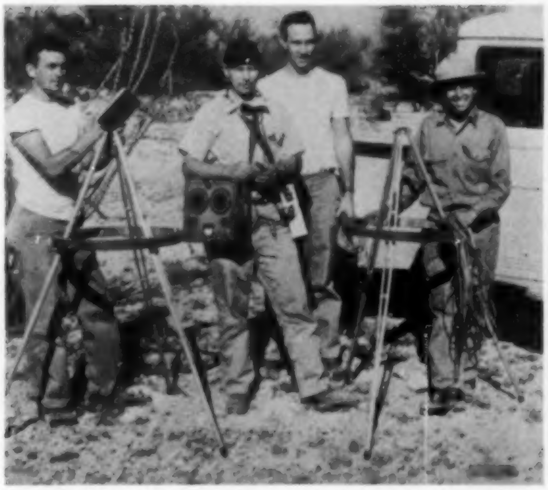
Equipment is made for any type of application and costs vary accordingly from $10 to $10,000. It is the cheapest aerial method available today.

Geochemical Methods: Although geochemistry has been in use since about 1930, it is considered one of the newest aids. Major work during recent years by the USGS and others has improved and advanced the technique considerably. Cheap, accurate, fast, and routine procedures are now available for many important metals.

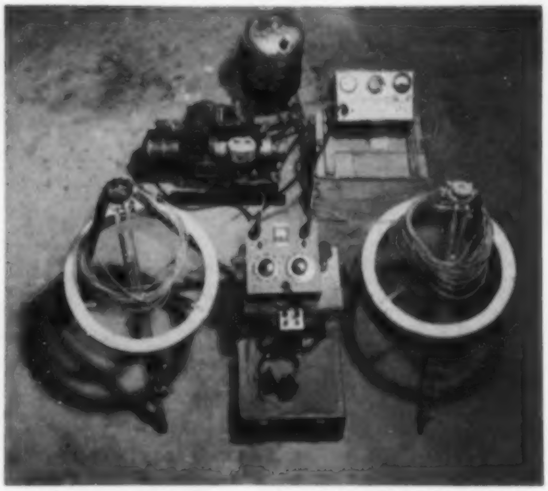
The principle employed takes advantage of dispersion phenomena of weathering products from a deposit and traces them back to their source. This is done by following the lead of water-sample determinations upstream, or by grid-plotting results from soil and plant samples. Generally, the method is



Self-potential apparatus used in measuring spontaneous polarization of rocks.



United Geophysical Corp.'s crew about to go into action with equipment shown at right.



Electromagnetic equipment . . . Somewhat similar in style and appearance to equipment used in other electrical methods.

only applicable in areas undergoing active weathering and where the cover is shallow.

Exploration costs run about $5 per determination with about 20 determinations per man-day. It is one of the cheaper ground methods available.

Additional Techniques: Geothermal measurements provide another method of theoretical importance. Continuing work in this field has resulted in some advancement.

Physical-property testing and model studies are of use in most of the methods. They are particularly important in research and interpretation. Improved equipment and new data resulting from this type of work have aided field applications considerably.

Activity in 1955: Total world-wide expenditures in all phases of mining geophysics may have reached $10 million in 1955. Total recorded investment exceeded $6 million for approximately 7000 man-months of work.

Aerial magnetic work accounted for the largest share (more than $1 million) of the total investment. Research represented about one fourth of the total in time and personnel. In decreasing order, division of money spent is as follows: aerial magnetic, research, electromagnetic (all types), ground magnetic, geochemical, seismic, natural-potential, gravity, radioactivity, and resistivity. Actually, the relative position of radioactive methods should probably be much higher because of considerable unreported activity in this field.

Canada led the world in money spent and in man-months of effort. In decreasing order, Canada spent more than one third of the total, Europe (including the Mediterranean area), almost one third, the U. S. one fifth, followed by Africa, Australia, Asia and South America.

Present Conditions: Most of the larger domestic mining firms now have established mining geophysical groups or departments and many petroleum firms have also entered the field. Several qualified organizations provide contract aerial work of all types. Many contracting exploration companies that have specialized for many years in petroleum seismology have now expanded their services and research to include mining applications. A few small companies provide contract services devoted almost exclusively to mining. Availability of consultants has somewhat improved, but really experienced and qualified personnel are relatively scarce. Substantial activity by governmental agencies continued during 1955.

In many ways, and particularly in new discoveries, Canada continues to lead the industry, having better general exploration favorability, better applicability for geophysics due to large areas of thin cover, and more risk capital available.

One factor that would improve domestic utilization relates to currently proposed changes in Federal mining law. These would allow temporary staking of so-called geophysical claims and possibly partial acceptance of geophysics as assessment work.

Conclusions

Application of geophysics in mining has increased considerably during the last several years. Important advancements have been made in uses, methods, and equipment. Significant research programs continue to strive for further improvement. Greater acceptance of the utility of geophysics by mine management is a noteworthy fact. Better mutual cooperation with geologists and the use of geology is a significant improvement which should be maintained. Through increased use, valuable application experience has been gained. High level of exploration activity and successful results account mainly for the increased interest. General world economy and the uranium boom have also contributed.

The fact that geophysics is now generally accepted in industry means that its future will be proportional to its contribution to new discoveries. As surface leads diminish or become more complex and expensive to test, the opportunity for contribution by geophysics should increase.

A reasonable continuation of these developments seems assured. If so, an optimistic future for the field of mining geophysics is predicted.

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by Ralph S. Siegrist

Cold Bent Steel

FOR the past 30 years the construction industry has used steel supports in rock and soft ground to expedite driving tunnels under many difficult conditions. The industry has had a definite advantage in that it bids its work in accordance with the type of job to be encountered. The mining industry has had to keep its progress in line with the economics imposed by the price of the commodity it mines.

Even so the mining industry, particularly metal mining, has been using steel support. Timber was universally used because of availability and cheapness, but as timber became scarce and labor more expensive—it takes more time to erect timber support—steel gradually replaced timber.

Steel supports first replaced timber in a cap and leg set common to most mines and was used only in main entries that were to stand for years. As pointed out even at that time, "Steel sets are only about one-third as heavy as wooden sets of equivalent strength; their erection not only requires less time, but also less physical effort."[1]

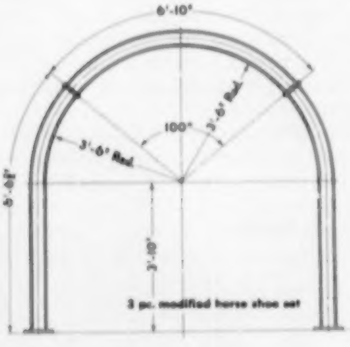
R. S. SIEGRIST is with the Commercial Shearing & Stamping Co.

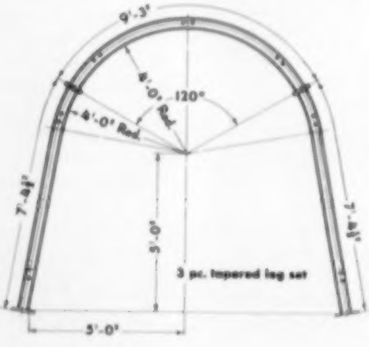
More recently, beginning in 1945, straight steel caps and legs were used in the Mather mine *A* shaft, operated by The Cleveland-Cliffs Iron Co., Ishpeming, Mich. These sets proved successful in some places but in others, as loads came on the sets, the straight cap and battered legs became deformed.

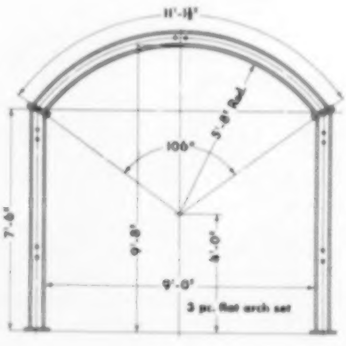
Support of main haulageways in mines follows the same pattern as that used by contractors on construction work. The support must be shaped to fit the ground conditions. The natural arching action of the ground is known from geology. It is also known that different geological formations have different arching actions. It is logical, therefore, to follow the contour of the ground arch with support.

Years ago the Commercial Shearing and Stamping Co. realized these conditions and started bending steel supports to fit them. During these years the company has gained considerable experience in using steel support under various conditions.

A design with cold bent members will better take the load because cold working raises the elastic limit of ordinary structural steel from a minimum of 33,000 lb psi to a figure close to the ultimate







Mine Supports

When circular sets were first used they were tied together with steel angles to form a structure, as pressure was applied and lagging would not fail because sets were tied together, the sets began to deform. This was corrected by eliminating the tie rods or steel angles and making use of double sets spaced wider apart.

strength, which ranges from 60,000 to 70,000 psi. Also, the yield point is practically eliminated.

A three-piece set with bent crown and tapered legs is used in medium heavy ground where all the pressure is vertical but not enough to deform the legs near the foot. The taper permits more clearance at the bottom and keeps arch excavation to a minimum. In ground too heavy for the tapered leg set a semicircular set is used. Where minimum support is required, the bent flat arch crown is adequate.

In one three-piece set the steel legs are slightly arched so that all segments of the steel are cold bent. This structure permits the same clearance as the former timber set with three-piece crown and two legs.

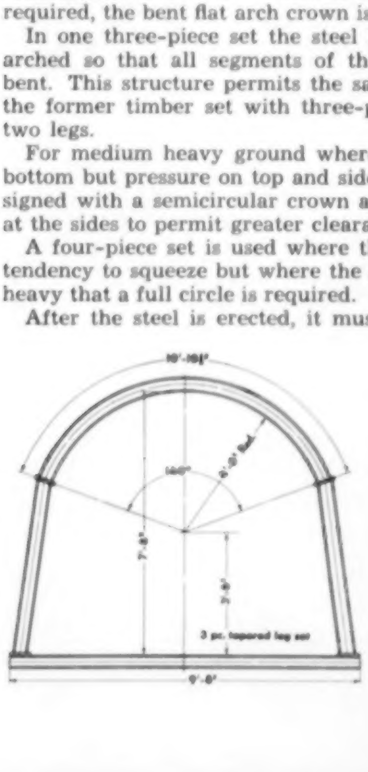
For medium heavy ground where there is stable bottom but pressure on top and sides, the set is designed with a semicircular crown and with a bulge at the sides to permit greater clearance.

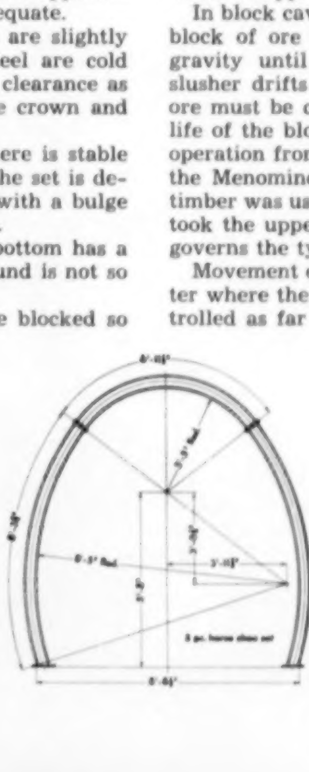
A four-piece set is used where the bottom has a tendency to squeeze but where the ground is not so heavy that a full circle is required.

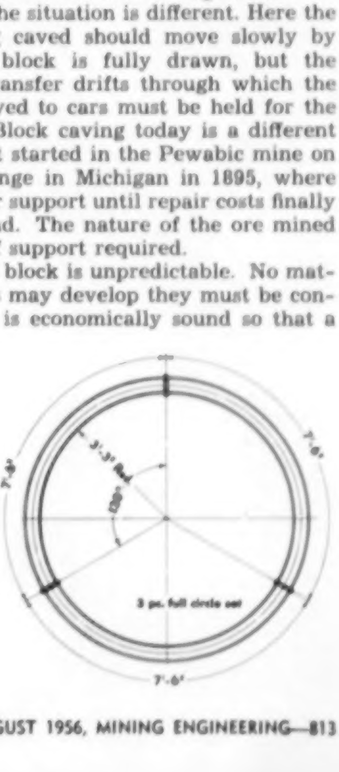
After the steel is erected, it must be blocked so that the ground load is immediately brought upon the steel support. In a given rib the bending moment depends on the spacing of the blocking points and varies as the square of the spacing. The passive resistance of the ground will prevent the ribs from changing shape when properly blocked and wedged and the ground will be held. Any support, to be successful, must be blocked. These facts hold for permanent support that is to remain a long time.

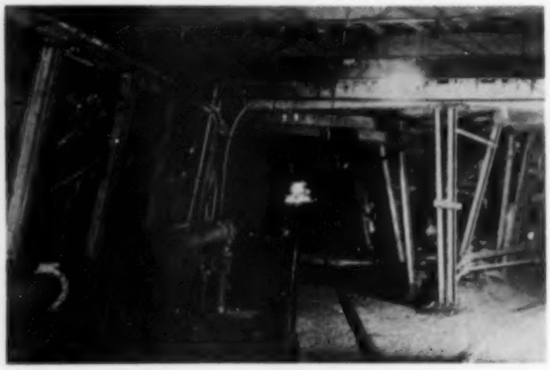
In block caving the situation is different. Here the block of ore being caved should move slowly by gravity until the block is fully drawn, but the slusher drifts or transfer drifts through which the ore must be conveyed to cars must be held for the life of the block. Block caving today is a different operation from that started in the Pewabic mine on the Menominee Range in Michigan in 1895, where timber was used for support until repair costs finally took the upper hand. The nature of the ore mined governs the type of support required.

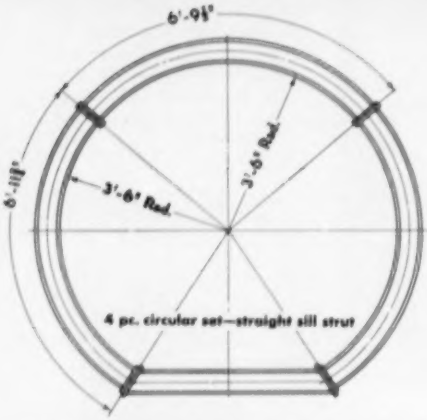
Movement of the block is unpredictable. No matter where the loads may develop they must be controlled as far as it is economically sound so that a

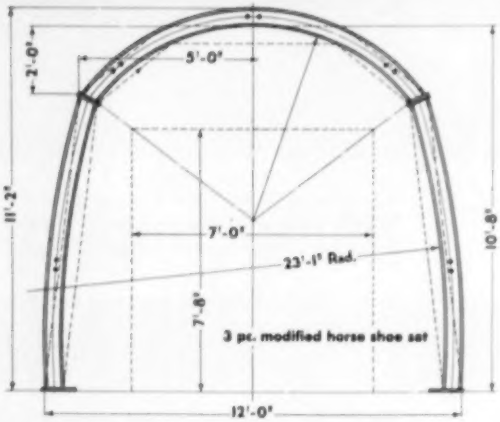












LEFT: Four piece circular set being used in very heavy squeezing ground. UPPER RIGHT: These sets proved successful in some places but in others, as loads come on the set, the straight cap and battered straight legs began to deform. BOTTOM RIGHT: This three piece is used medium heavy ground where the bottom is stable.

steady draw of ore may be maintained. For such loads a full circle design of steel support is recommended. It is known that a pound of steel support in the form of a circle will carry almost twice the load it will carry in the form of a straight-legged rib.

The simplest full circular set consists of three identical, interchangeable pieces so that inventory trouble is minimized. The Miami Copper Co. at Miami, Ariz., started using these sets in 1950. It was found that they work well in highly altered rock that tends to flow under weight and thus snugs in the whole set, including the steel and lagging. Installation was found to be easier than for standing timber and a more uniform draw of ore was maintained. The circular steel sets used were 4-in. H at 13 lb per ft, replacing 10x10-in. timber cap and leg sets.

Circular sets can be used to replace timber that has closed in, making production impossible. Spacing of the steel sets is governed by the nature of the ground and position of the mill openings. Local timber poles are used for lagging, with the steel sets spaced so that the lagging will fail before the steel set shows signs of deforming. It is realized that the loads are such that it is not economically sound to try to hold the ground. It is also realized that there are only two ways of relieving the pressure built up in a block—by drawing the ore from the drift or permitting the lagging to break.

When the circular steel sets were first used at Miami, they were tied together with steel angles or tie rods to form a structure. Then when pressures built up and the lagging could not fail because the sets were tied together, the sets began to deform. Deformation passed from one set to another throughout the structure so that they moved like dominoes toppling one against the other.

This fault was corrected by eliminating the steel ties from set to set and by using double sets spaced further apart with lagging only between the double sets. This method of installation is now used where the ground is known to be very heavy. Single sets tied together in a structure are being installed in mines where ground conditions permit.

Heavy ground snugs in around the steel sets. Sections of steel used should be kept to a minimum so that less resistance is offered to the squeezing ground.

In Michigan's Upper Peninsula, The Cleveland-Cliffs Iron Co. started using a modified circular steel support about the same time as Miami Copper Co. The three top pieces are circular and the bottom piece is a straight strut. Adapted to the very heavy squeezing ground, it can be made any inside diameter but not smaller than 7 ft.

At first the miners, accustomed to installing timber sets, had difficulty with the steel support, but when they realized the ease with which it could be handled and the safety it afforded they became staunch advocates. The speed with which steel supports can be installed has increased development rate in block caving, and the fact that slusher drifts are kept open has increased rate of draw toward complete recovery.

Reference

[1] Carnegie Stell Co. pamphlet Steel Mine Timber, 8th ed., Jan. 1, 1935.

Stoping Methods at Magma

by B. Van Voorhis

SUCCESSIVE changes have been made in stoping methods at the Magma mine. Factors that have made these changes advisable are: vein width, heavy and swelling wall rock, abnormal rock temperatures, ventilation, labor costs, timber costs, mining speed, and labor-saving mechanical developments. Additional localized conditions, such as low angle post-mineral faulting and selective mining, have also made changes necessary. A stoping method with enough flexibility to meet most of these conditions has been in use for the past ten years.

The Magma Copper Co. was organized by the late William Boyce Thompson in 1910 and acquired by purchase and location several groups of contiguous claims, among them the Silver Queen property. The Hub and Irene claims acquired in this purchase cover the apex of the vein, and all stoping done up to 1920 was from these two claims.

Type of Ore Deposits: The Magma fault, which is the locus of the Magma vein, is a deep-seated fissure that has a strike of about S 80° W. Its dip averages 70° to the north from the surface to the 800 level, vertical from the 800 to the 900 level, about 78° to the south from the 900 to the 4000 level, and with a slightly flatter dip to the south below this elevation. Its reversal of dip occurs where the dominant wall rocks change from sedimentary beds to diabase.

The second type of ore deposit, from which about one third of the present production is now being mined, is a mineralized bed in the Devonian Martin limestone that occurs from 10 to 25 ft above the contact of this limestone and the underlaying Troy quartzite. These sedimentary beds strike north and south and dip from 28° to 34° to the East.

Early Stoping Methods: Before 1910, small isolated bodies of high grade ore were developed and stoped between the 400 level and surface. The mining and timbering method used is not known, as these workings were inaccessible at the time this company took over the property.

Most of the ore mined by the present company above the 800 level was stoped by the rill or inclined cut and fill method. Development raises were driven in the ore to the level above on 75-ft centers, the block between being considered one stope. The sill floor was then mined and a mat of double 2-in. lagging laid on 8x8-in. stringers. The back of the stope was then mined to slope upward from the center of the block to the raise at each end on the angle of repose of the subsequent fill. This first ore was hand mucked into cars on the sill floor. When the ore was removed, two timber sets were stood in the center of the stope to form the bottom of the extraction raise. These sets, as well as the raises at the ends of the stope, were then lagged on the outside with 2-in. lagging. Waste from development work or the surface glory hole was run in from the level above through the two end raises. This waste-fill was covered with a plank floor, and a 6-ft slice was mined, working from the low point of the back at the center of the stope towards the raises at each end. When a cut was completed, the broken ore was drawn from the stope, the plank floor was taken up, and the extraction raise was cribbed to within 2 ft of the back and the stope was again filled.

This method worked well under the following conditions: A narrow vein, 5 to 15 ft wide; a silicified and well drained ore; and vein walls comparatively free from crushing and gouge.

Shrinkage Method: The shrinkage method was tried on the west 1600 level in a block of ore that appeared adaptable to it. The method was soon abandoned, and the reasons for its failure were the abnormal rock temperatures, inability to ventilate the stope properly, and rapid oxidation of the broken sulfide ore.

Veins more than 15-ft wide

Rill Stope and Pillar System: Conditions began to change below the 800 level, for development proved the vein width in the main ore shoot to be more than 15 ft in many places, and the hanging wall rock required immediate support after the ore was removed. Two general mining methods were put into use: the timbered rill where the vein was less than 15 ft wide and a combination rill stope and pillar system where the vein was more than 15 ft wide.

This latter system was a combination of 16-ft rill stopes, alternating with 14-ft pillar stopes. An extraction drift was driven in the ore along the footwall of the vein. From this drift, crosscuts were driven on 30-ft centers to the hanging wall across the vein. These crosscuts were then widened out 8 ft on each side, and the back was blasted down to a height of 10 or 12 ft, forming the sill floors of the rill stopes. The length of each stope was the width of the vein, which varied from 15 to 60 ft.

The extraction drift was timbered with battered sets, and the three sets next to the footwall of each 16-ft rill stope were carried up as a three-compartment raise as mining progressed. The outside sets were lined and used as ore chutes and the center set was used as a manway. These ore chutes and the manway were used later for extracting the pillars.

Square sets were placed across the vein on one side of the rill stope on the sill floor, and single 8-ft posts of 10x10-in. timber were stood across the vein on the opposite side to form the gob lines. When the stope was filled the square sets were held open as a crosscut, a means of access for future stoping operations from below, and also as access to the hanging wall drift.

After all sill floor timbering was completed, a cribbed raise was started in the hanging wall of the vein. Broken waste from this operation was dropped into the stope as fill, and when this fill reached within 4 ft of the back of the stope the raise work was

B. VAN VOORHIS is Chief Engineer for Magma Copper Co., Superior, Ariz.

stopped, a floor was laid on this gob, and a 7-ft cut of ore was mined. The back of the stope was inclined upward to the hanging wall, its slope roughly paralleling the angle of repose of the waste fill, about 35°. Hand mucking, mechanical shovels, and dragline scrapers were used to load the ore into cars on the sill floor until the stope was high enough for the ore to run by gravity into the chutes.

After the ore was cleaned out, new gob lines consisting of single posts end on end and 2-in. lagging, were placed along each side of the rill stope. Ends of the post were framed in half and a single strand of old hoisting cable was used to tie together corresponding posts on opposite sides of the stope, the cable passing around the joints of the posts.

The waste raise advanced only as fill was needed in the stopes, usually reaching the level above when the stope was about 35 ft high on the hanging wall side. When the raise approached the level above, it was inclined away from the vein so as to connect to the near side of the hanging wall drift. At one time the cribbed raises were driven in the ore, but because of the extremely high cost of such raises, since the ore was harder than the wall rock, the practice was discontinued.

When the stope approached the level, square setting was used to extract the ore directly under old filled stopes.

The pillar between the filled rill stopes was extracted by a slicing method, which was a modified form of the Mitchell slicing system used in Bisbee, Ariz. In using this method, the top of the pillar was shot out, and a line of segment sets were placed immediately below the filled sill floor of the finished stope above.

The pillar was mined on about a 40° slope downward towards the footwall; the broken ore moved by gravity into the square-set raises which were used by the adjoining rill stope. As mining progressed, 10x10-in. stringers were placed across the stope every 7 ft vertically, and upon 5-ft centers horizontally between corresponding rill stope posts. Only enough ground was broken at one time to make room for one stringer. As a precautionary measure, vertical segment sets were placed every 50 ft; then if the ground started to move, a floor was laid at this point and the top of the stope was filled with waste.

Wherever the vein was wide enough, the combination rill stope and pillar system was used from below the 1600 to 2800 level in the west orebody. A few variations from the above method were tried, but these will not be described here.

A combination of adverse conditions caused this stoping method to be discontinued below the 2800 level. The raise cost was high due to the number needed, as raises were driven on 30-ft centers along the strike of the vein. The wall rock became progressively weaker in depth, so the stope raises could not be driven in the hanging wall. Since heavier wall rock also caused considerable trouble when the pillars were mined, it was necessary to stop mining and fill the pillars between levels. The timber holding the gob in filled stopes was often found crushed, causing gob runs from the filled stopes into the pillar. Then too, the average width of the vein in the ore shoots on the lower levels more nearly approached 15 ft. One additional factor that increased the cost of mining the pillars was a rule put into effect that blasting could only be done at the end of the shift. The pillar crew's efficiency was impaired by this rule, because mining could not be continuous, as many large boulders were being uncovered that had to be blasted.

Veins less than 15-ft wide

Timbered Rill System: This mining method was first used at the Magma back in 1916 on the 900 level. Numerous variations were adopted to meet the changing conditions as mining progressed downward. In the west orebody, between the 800 and 1600 levels, the method was used as follows: In developing a block of ground, crosscuts were run through the vein from the footwall drift at intervals of 150 ft. From these crosscuts an extraction drift was driven in the ore along the footwall of the vein. Stopes were silled out from this drift and timbered with square sets. The outside of the extraction drift was lagged to prevent the fill from running into the drift. Pony sets over the extraction drift were also kept open for chute loading platforms.

The length of each stope along the vein depended upon the width of vein and character of the ore. Generally a 30 to 40-ft stope was started, and the back inclined from the top of the sill at each end to four or five sets in height at the center. From the top floor a two-compartment cribbed raise was driven in the hanging wall next to the vein. After this raise was holed to the level above, it was used for a waste fill passageway, for lowering timber and supplies into the stope, and for an airway. At each end of the stope, the two square sets were left open—one lined with 2-in. lagging and used for the ore chute, the second used for a manway. They were oriented with their long axis across the vein if the vein was two sets wide or more; otherwise, parallel to it. Occasional offsets kept these raises next to the footwall. Grizzlies made of square-set caps spaced 9 in. apart were placed over the ore chute. Filling was stopped before the waste covered the tops of the square sets, so that succeeding sets could be placed without digging. The angle of slope of the fill, the angle of repose, was roughly two sets horizontally to one vertically. After filling, a floor of 2-in. lagging was laid on the waste, and pieces of lagging were used for sills or nailing strips.

A 6 or 7-ft cut was then taken from the back, starting at the ends over the extraction raises and working upward towards the center. Square sets were stood as soon as room was made. The broken ore moved down the floor and into the chute by gravity, very little shoveling being necessary. Large boulders were broken on the grizzlies. Usually three such cuts were taken before the stope was again cleaned and filled.

Succeeding adjacent stopes were generally 15 to 25 ft in length. These stopes were silled out as before, and the back was given a downward slope away from the filled stope corresponding to the angle of repose of the waste. The timbering operation and the carrying upward of the ore chute and manway were the same as already described. The waste fill was run into these stopes through the extraction raise of the adjoining completed stope.

A variation of this method was used where the ground would stand sufficiently well. The vein was silled out for a length of ten sets and a height of two sets above the sill. After this space was timbered, the back was pyramided to a height of about eight sets at the center. From this point a waste raise was run in the hanging wall to the level above. Just enough ore was mined by this first operation to provide room for the waste from the driving of the

raise. The stope was then mined to a height of about eight sets at the ends. Then wing stopes were started at each end, four sets long and mined up eight sets. In this way a block of 18 sets or 90 ft along the vein was mined and filled by one waste raise. When this method was used pillars of ore 15 ft long were left between adjoining 90-ft stopes. The pillars were recovered by the slicing method already described.

Another variation of this method was used from the 2800 to 4400 levels. This was the adoption of alternate 90-ft stopes and 15-ft pillars, regardless of the width of the vein. This change was made because of the practicability of the 90-ft stope and wing system. The sill floor mining, mucking, and timbering were then done as previously described. Stope raises were driven next, one on the footwall in the vein at the center of the 90-ft block. This put the raises on 105-ft centers along the strike.

Raises were driven in the footwall of the vein rather than in the hanging wall next the vein, as formerly, because of the weakness of the wall rock. This made it much easier to fill the stope completely, especially wherever the vein was wide, but this location necessitated the driving of a hanging wall drift. Raises were timbered with 6x6-in. cribbing. Stoping and waste filling operations in mining the block were done in the same manner.

It was found necessary to make a change in the method of mining the pillars, due to the weakness of the wall rock, so the square-set method was put into practice. This method enabled the waste fill to be kept fairly close to the back. Fill was run into the mined-out area through the extraction chute of the adjoining and completed stope.

Flexible System Needed

Present Stoping Method—Vertical Slice or Slot System: Mining has become more and more difficult as subsequent levels have been developed. Below the 4000 level and in the west orebody the wall rock is schist. This rock is exceedingly weak; also the vein material in this area needs immediate support after being opened. These conditions have made a change in the stoping system advisable, a system flexible enough to meet the adverse conditions mentioned above.

The extraction drift is driven in the vein. The type of drift sets used depends upon the vein width, the physical characteristics of the ore, and the wall rock. The sill floor mining, mucking, and timbering is now done. Either a stoper machine or a Leyner-type drill mounted on a vertical bar with a crossarm is used for drilling. Mucking is done by an air-driven rocker type loader.

The raises are now driven on the footwall in the vein and are timbered with square sets. Offsets are made wherever necessary to keep the raise on the footwall. Raises are spaced to fit the block of ground to be mined; in a long block it has been found that 105-ft centers are good practice.

In the slot system the length of the stope is three or more lines along the vein depending on the width of the vein. The mining of the slot progresses similarly to the method of square-set mining. The ground is broken by breasting out, either from the stope raise or from the open line of the preceding slot. This slot is carried upward for five floors before filling, though on occasions it has been necessary to fill with fewer than five floors mined. The ore is extracted, for the first cut, through temporary chutes in the sill sets. When the cut is completed and the stope cleaned out, the waste fill is run into the stope through the raise or the extraction chute of the adjacent stope. The end line of the slot is left open for the chute and manway, and a permanent Verde-type chute installed in the extraction drift for car loading. Flooring over the fill and the grizzlies on the top of the extraction chute is the same as for the timbered rill stope.

In a normal cut of five floors, breakers are placed on the third floor of the cut. These consist of two square-set caps per set equally spaced in the set. The entire floor is covered with these breakers. In hard ground the breakers are kept one floor below the mining floor. These breakers protect the timber below from large boulders that may break off or produced by poor fragmentation of the stope round.

In filling the slot it is desired to fill three lines from the footwall to the hanging wall. To do this when starting a slot from the level, it is necessary to mine a five-line slot. This allows the three center lines to be filled, and the outside lines to be left open for mining the adjacent slots. In starting a slot from the level, the two stope raise lines and three adjacent lines comprise the five-line slot. When this five-line slot has been mined about ten floors above the level, the adjacent slots may be started.

Before a cut is filled, it has been found necessary to tie the posts together with cables. Several gob runs occurred while the adjacent stope was being mined until this was made standard practice.

In the open line used as a chute and manway, succeeding sets are floored and lagged to form a big stairway from the hanging wall side towards the footwall. This stairway steps the broken ore towards the extraction chute and also protects the girts exposed in the open line. In wide stopes, in addition to the stairway, alternate sets are floored with 2-in. lagging to protect girts not included in and above the stairway.

The vertical slice or slot system was adopted at the Magma mine for several reasons. Chief among these was a need for flexibility in the stope cycle, due to the weak walls and the weak and broken character of the ore on the lower levels. The slot can be mined flat or it can be mined vertically a line at a time, depending upon the strength or the weakness of the ore. The height of the cut may vary depending on ground conditions. Another advantage of this system is that it allows a more rapid extraction of the ore from a given block, because there are more faces available for mining. This is an important factor; it helps prevent the stope timber from riding, the gob line timber from breaking, and sulfide ore from oxidizing.

Because the mining method now being used in the limestone replacement deposit is in the experimental stage, it will not be described here. It may be mentioned, however, that roof bolting is being tried in conjunction with the timbered sets, not only in the extraction drifts and raises, but also in a number of the stopes.

Conclusion

The Magma mine has been worked continuously for the past 45 years and the mining method now being used has been a slow evolution from several systems used in the past. The vertical slice or slot system more nearly meets the many adverse conditions encountered at this time. As deeper levels are developed, it probably will be necessary to modify this system.

Performance of Shell Liners in Ball Mills

by Frank J. Windolph

Grinding Practice—These tests were run in the 9 ft diam by 8 ft long grate discharge ball mills at Climax. Each mill functions in closed circuit with a 78 in. Akins duplex high-weir classifier, and a circulating load of 300 pct is maintained. The size of the mill feed is 6 pct on 3/8ths, which is ground to pass 28 mesh.

Testing Methods—Each grinding section is equipped with a conveyor scale on the ball mill feeder belt, a watt-hour meter on the ball mill motor, and an automatic sampler for the ground product. These instruments are exceptionally valuable to the mill testing program.

It has been found necessary to run a control mill with each test. The liners are tested over the same period of time to eliminate the variables of feed size and grindability of ore. The mill speeds must be identical, and each mill must use the same size and kind of grinding balls. The pulp density in the mill and the circulating load are held constant, and at times, the mill operators have been rotated to eliminate the human element. The values for liner consumption were calculated from the original liner weights.

FRANK J. WINDOLPH is Assistant Mill Superintendent, for Climax Molybdenum Co., Climax, Colo.

Description of Tests—

Table I compares the thin shiplap liner to a single wave liner.

Table II demonstrates what happened when the shiplap liner was run in the opposite direction.

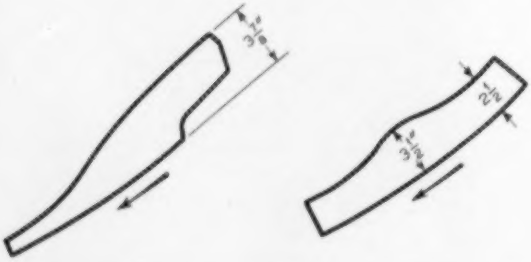
Table III exhibits the difference in results obtained with the thin shiplap liner and a double wave liner of approximately the same weight.

Table IV shows the effect of mill speed on liner wear.

Table V shows how the mill capacity varied with a change in the thickness of the standard Marcy Shiplap liner.

Table VI displays the performance of a liner with spiral lifters.

Thin Shiplap vs. Single Wave



The single wave liner did not perform as well as the shiplap at 78 pct of critical speed.

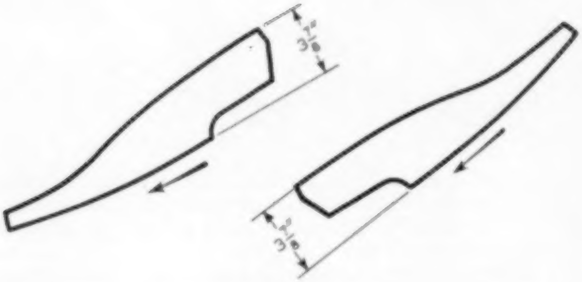
Table I. Shell Liner Comparison

Type of Liner	Thin Shiplap	Single Wave
Sets tested, no.	2	1
Weight	25,300	26,000
Mill size	9x8-ft Marcy	9x8-ft Marcy
Mill, rpm	20	20
Type of discharge	Grate	Grate
Balls used	3-in. and 2½-in. forged	3-in. and 2½-in. forged
Tons	244,695	219,948
Life, hr	3,031	2,824
Product, percent of +100 mesh	44.5	44.2
Load, kw	390	400
Tons per hour at 42 pct +100 mesh	76.2	74.0
Kilowatt-hours per ton at 42 pct +100 mesh	5.12	5.41
Liner consumption, pounds per ton at 42 pct +100 mesh	0.110	0.124

This test compares the shiplap liner to a single wave liner of approximately the same weight. The single wave liner did not compare very favorably with the shiplap at 20 rpm. It probably did not have a high enough lift for this speed. In more recent tests at higher speeds, the single wave liner has equaled the thin shiplap.

This report reviews some of the many tests which have been conducted in the Climax Ball Mills in an effort to find the most economic shell liner design. As a result of this test program, it is now the practice to use one type of liner when mill capacity is the primary consideration, and a different liner for maximum economy during periods when excess mill capacity exists.

Thin Shiplap vs. Thin Shiplap Reversed



The shiplap liner should not be reversed in ball mills which run at 78 pct critical speed.

Table II. Shell Liner Comparison

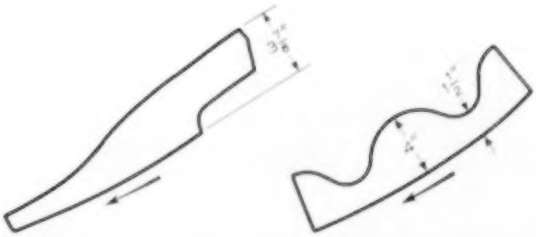
Type of Liner	Thin Shiplap	Thin Shiplap Reversed
Sets tested, no.	3	1
Weight	25,300	25,300
Mill size	9x8-ft Marcy	9x8-ft Marcy
Mill, rpm	20	20
Type of discharge	Grate	Grate
Balls used	3-in. forged	3-in. forged
Tons	266,401	285,810
Life, hr	3,233	3,986
Product, percent of +100 mesh	42.2	41.3
Load, kw	393	371
Tons per hour at 42 pct +100 mesh	82.1	72.8
Kilowatt-hours per ton at 42 pct +100 mesh	4.79	5.10
Liner consumption, pounds per ton at 42 pct +100 mesh	0.095	0.087

This test reveals what happened when the shiplap liner was put in backwards. The mill capacity was reduced by 11 pct and the power efficiency was lowered by 6 pct. The overall cost was high when the liner was used in this manner, even though the liner consumption decreased.

This test was conducted at a time when the proper liners were unavailable, and it settled an argument which had come up from time to time.

The lifting effect was too great here for the speed at which the mill was operated. The reversed liner would probably compare more favorably if the speed was reduced.

Thin Shiplap vs. Double Wave



The double wave liner displays low liner consumption, but gives less capacity than a shiplap liner of approximately the same weight.

Table III. Shell Liner Comparison

Type of Liner	Thin Shiplap	Double Wave
Sets tested, no.	4	3
Weight	25,300	24,200
Mill size	9x8-ft Marcy	9x8-ft Marcy
Mill, rpm	20	20
Type of discharge	Grate	Grate
Balls used	3-in. forged	3-in. forged
Tons	290,000	445,358
Life, hr	3,395	5,352
Product, percent of +100 mesh	42.5	43.1
Load, kw	404	382
Tons per hour at 42 pct +100 mesh	84.5	81.1
Kilowatt hours per ton at 42 pct +100 mesh	4.78	4.71
Liner consumption, pounds per ton at 42 pct +100 mesh	0.088	0.056

This test demonstrates the economy of the double wave liner. The power efficiency of the mills was practically the same, and although the mill capacity was reduced by 4 pct the low liner consumption is outstanding.

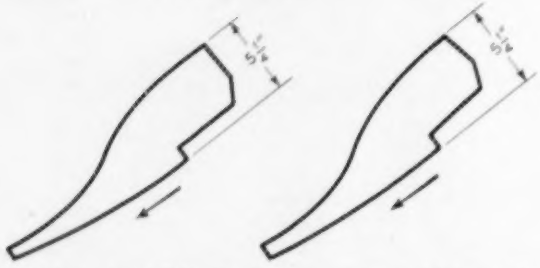
In this test, the lifting effect was altered by increasing the number of lifters. The next obvious step would be to go to a triple wave liner, which we have not tried.

The double wave liner does not fit into present operating plans, because it would reduce the mill tonnage by more than 1000 tpd. The use of the double wave liner is indicated when/if the mill capacity exceeds the demand.

(Continued on page 820)

Thick Shiplap at Different Speeds

Substantial liner savings can be made by reducing the mill speed from 78 to 66 pct of critical.



This test exhibits the liner economy which can be realized by running ball mills at slow speeds. These data are for different periods, and cannot be used to compare a low speed to a high speed mill, but they do indicate a sizeable reduction in liner consumption at the lower speed. The liner consumption was reduced 40 pct.

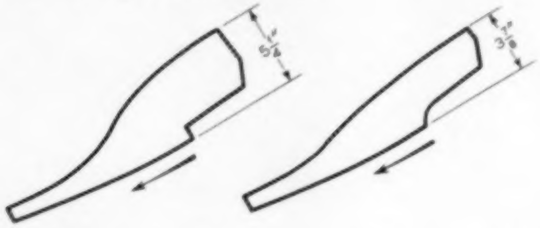
Substantial savings on shell liners can be made by reducing the ball mill speed from 78 to 66 pct of critical, and low speeds are used at Climax when the demand permits.

Table IV. Shell Liner Comparison

Type of Liner	Thick Shiplap	Thick Shiplap
Sets tested, no.	2	4
Weight	31,140	31,140
Mill size	9x8-ft Marcy	9x8-ft Marcy
Mill, rpm	20	17
Type of discharge	Grate	Grate
Balls used	3-in. forged	3-in. forged and cast
Tons	405,246	631,053
Life, hr	4,944	9,871
Product, percent of +100 mesh	42.6	38.2
Load, kw	384	329
Tons per hour at 42 pct +100 mesh	80.9	69.1
Kilowatt-hours per ton at 42 pct +100 mesh	4.75	4.76
Liner consumption, pounds per ton at 42 pct +100 mesh	0.078	0.046

Thick Shiplap vs. Thin Shiplap

Shell liners of thinner section can be used to advantage when extra mill capacity is needed.



The standard Marcy design for the Climax mills is 5¼ in. thick. When the thickness of this liner was reduced to 3⅞ in., an increase in mill capacity of between 4 and 5 pct was realized. The power efficiency remained the same even though the lifting effect of the liner was reduced with the thickness. Because of the higher scrap loss obtained with the thin liner, the liner consumption was increased by 13 pct.

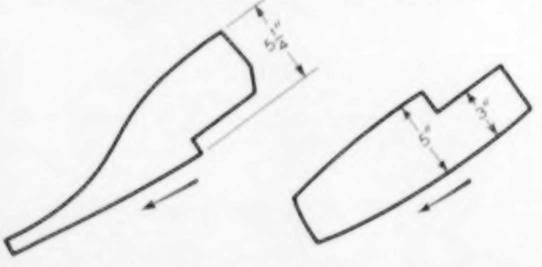
The thin shiplap liner is now used during periods when the mill is pressed for tonnage and yields an additional 1300 tpd in the 28,000 ton plant.

Table V. Shell Liner Comparison

Type of Liner	Thick Shiplap	Thin Shiplap
Sets tested, no.	2	2
Weight	31,140	25,300
Mill size	9x8-ft Marcy	9x8-ft Marcy
Mill, rpm	20	20
Type of discharge	Grate	Grate
Balls used	3-in. forged	3-in. forged
Tons	405,246	293,298
Life, hr	4,944	3,396
Product, percent of +100 mesh	42.6	43.0
Load, kw	384	404
Tons per hour at 42 pct +100 mesh	80.9	84.5
Kilowatt-hours per ton at 42 pct +100 mesh	4.75	4.78
Liner consumption, pounds per ton at 42 pct +100 mesh	0.078	0.088

Thick Shiplap vs. Spiral

The spiral liner shows preliminary evidence of increasing mill capacity by applying a different type of ball action.



The shell liner with a spiral lifter is a recent investigation at Climax. The liner was designed to convey the balls which are next to the shell toward the feed end of the mill. The shiplap contour was retained, so that a single variable was introduced. This liner gave increased capacity with about the same power efficiency, but the liner consumption was somewhat higher.

A revised design of the spiral liner has been tested at Climax. The new design has a thinner section and has possibilities of increasing capacity.

Table VI. Shell Liner Comparison

Type of Liner	Thick shiplap	Spiral
Sets tested, no.	2	2
Weight	31,140	34,720
Mill size	9x8-ft Marcy	9x8-ft Marcy
Mill, rpm	20	20
Type of discharge	Grate	Grate
Balls used	3-in. forged	3-in. forged
Tons	405,246	370,217
Life, hr	4,944	4,454
Product, percent of +100 mesh	42.6	41.9
Load, kw	384	400
Tons per hour at 42 pct +100 mesh	80.9	83.2
Kilowatt-hours per ton at 42 pct +100 mesh	4.75	4.81
Liner consumption, pounds per ton at 42 pct +100 mesh	0.078	0.094

Corrosion Problems in Pumping Acid Mine Water

by C. D. Clarke and G. Reinberg

MOST underground mining operations are dependent on pumping installations to keep the mine unwatered. The reliability of such installations is obviously of paramount importance. The volume of water to be handled is often considerable, and the total head is relatively high. In these cases, both capital cost and operating expense of the pumping installations will become significant factors in overall mining costs.

To insure reliability and to keep efficiencies, and hence operating costs, within acceptable limits it goes without saying that mechanical maintenance of a mine pumping installation must receive scrupulous attention at all times. Large mine pumping installations today almost invariably use multistage centrifugal pumps, since positive-displacement units would not be economically competitive except under very unusual conditions of small volume combined with extremely high heads. Centrifugal pump maintenance, under ideal circumstances, would be confined to parts subject to normal running water, i.e., bearing surfaces, stuffing box packing, and shaft sleeves. Under adverse conditions, however, metal may be lost from the wetted surfaces of a pump by erosive or corrosive action of the pumped fluid, and maintenance costs can easily attain enormous proportions.

C. D. CLARKE, Member AIME, is Mine Superintendent at Cerro de Pasco Corp., Peru. G. REINBERG, Member AIME, is a Consulting Engineer, New York City.
TP 4252A. Manuscript, Feb. 20, 1956. New York Meeting, February 1956.

The following definitions are those most generally used for the phenomena encountered.

Erosion is a general term meaning mechanical removal of material from a surface. As applied to pumps, it may be the result of simple abrasion, such as that produced by suspended solid matter in the liquid being pumped. In common with other hy-

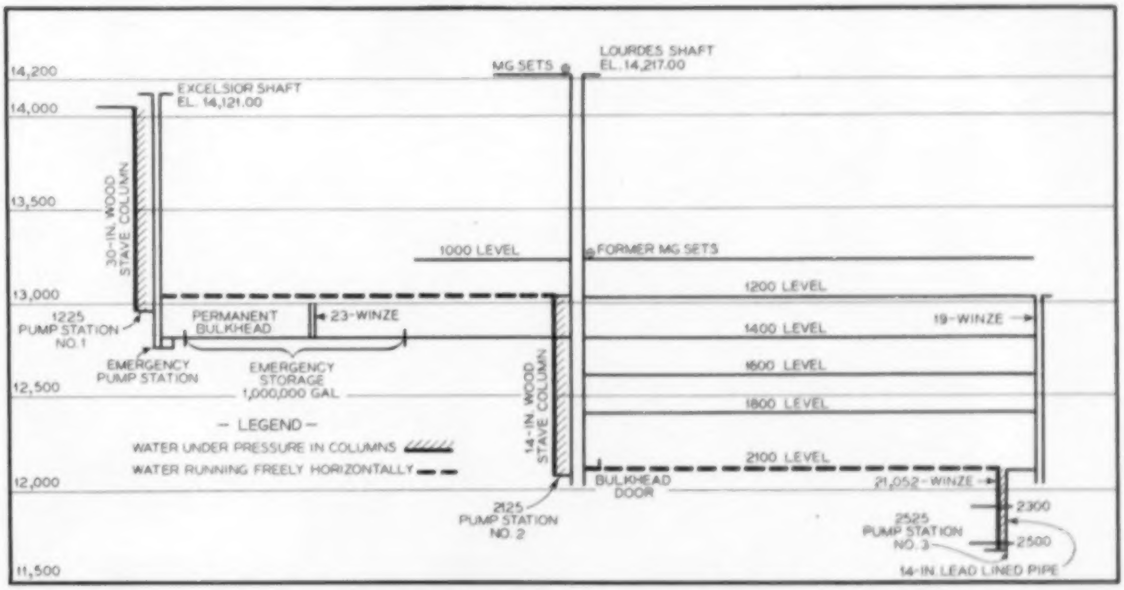


Fig. 1—Cerro de Pasco mine drainage section, acid water pumping system. Station 1: three 8-in., three-stage SD volute pumps, 800-hp motors, 1190 rpm. Capacity 2000 gpm against head of 1040 ft. Station 2: same as pump station No. 1. Station 3: one 8-in., two-stage SD volute pump, 500-hp motor, 1190 rpm. Capacity 2500 gpm against a head of 500 ft.

The Transactions papers appearing in MINING ENGINEERING during 1956 will subsequently appear in AIME Transactions Volume 206, and may be permanently referenced to that volume.

draulic machinery, however, pumps are also subject to a special and often very severe type of erosion resulting from cavitation. Cavitation is encountered when the absolute pressure at some point in a body of liquid falls to a value lower than the vapor pressure of the liquid at that point, causing the formation of a bubble of vapor, which is suddenly condensed when the conditions which caused the formation of the bubble are reversed. The collapse of the vapor bubble causes an impact shock capable of producing extensive erosive damage in areas where cavitation is persistent.

Corrosion is the result of chemical action, the material of the corroded surface being converted to a compound, which leaves the surface either in solution in the corroding fluid or by subsequent erosion. It is convenient practically, though not scientifically rigorous, to distinguish between three types of metallic corrosion: 1) *chemical,* meaning the case in which the metal combines with anions in the corroding fluid by virtue of its own electrolytic solution pressure; 2) *electrolytic,* if the corrosion is produced by current flowing from an outside source; and 3) *galvanic,* a special case of electrolytic corrosion in which the source of corroding current is a primary cell formed either by the contact of two metals of dissimilar solution potentials with each other and with a common electrolyte, or else by the contact of a single metal with an electrolyte of varying concentration.

It will be apparent that almost any combination of such deleterious conditions may arise in mine pumping installations. The avoidance of cavitation under normal operating conditions is essentially a design limitation, but also requires that liquid be supplied to the pump suction at an absolute pressure safely above the net positive head (NPSH) required. For a given pump design, the required NPSH is a characteristic function of the discharge conditions. The difference in elevation of the pump centerline and the water surface in the suction sump which will provide the required NPSH is a function of the water temperature, the barometric pressure, and the friction losses in the suction piping. All these factors must be properly correlated in planning an installation and fixing its operating limits. Under adverse conditions, such as high-water temperature, high altitude, or unavoidable suction lift, the only economical solution may be to use low-head booster pumps to supply water to the main pumps, but it is naturally preferable, if at all possible, to provide for an adequate minimum elevation in the suction sump. Local cavitation may also arise at times from some abnormal condition such as high velocity leakage due to wear or gasket failure and this will result in rapid and widespread erosion unless prompt corrective measures are taken.

Erosion caused by the presence of suspended solids may be difficult to avoid in some mine pumping systems, though provision of sumps of adequate settling capacity and a means of cleaning the sumps when required usually gives sufficient protection. This point requires special consideration when potentially corrosive conditions are also present.

Chemical corrosion is a potential hazard in the case of many metal mine pumping systems. Ordinarily acid mine water does not contain free acid radicals, but carries in solution metallic salts such as those of copper, which make such water corrosive to any less noble metal which can chemically replace the dissolved metal ions. Such waters have a low pH, due to hydrolysis, and also provide an electrolyte of high conductivity in which galvanic couples can occur, unless great care is exercised in the selection of materials of construction. Pumps having all wetted parts of selected bronze compositions are satisfactory in many cases, but the superior chemical and mechanical properties of more expensive stainless steels of the 316 or higher alloy types often justify their use. This question is particularly worthy of consideration in the case of high head installations, where use of the more expensive metal may permit the selection of higher rotative speeds and hence pumps of smaller physical dimensions and cheaper driving motors.

Although a metal may resist chemical corrosion or mechanical abrasion when either condition is

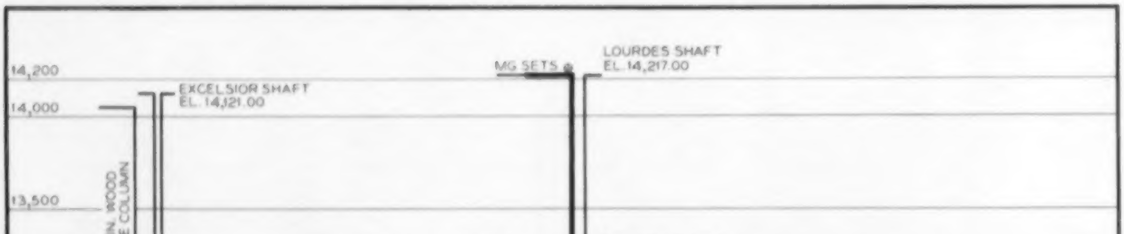


Fig. 2—Cerro de Pasco mine negative ground line system. See caption, Fig. 1, for data on pump station equipment.

present alone, it is usually unsatisfactory for pump construction when both effects are present. Many metals and alloys develop a passivity to chemical corrosion under static conditions, by virtue of the formation of an insoluble and impervious surface layer of a compound which is a product of the initial chemical corrosion of the clean metal surface. In cases where this layer is continually abraded or eroded to expose a clean surface, both corrosion and erosion continue at a rapid rate, although neither process could continue in the absence of the other. For this reason, special care must be taken in selection of materials for pumps which are subject to both corrosive and abrasive conditions.

Electrolytic corrosion by stray current from outside sources is an added hazard in certain instances, particularly with underground installations. In metal mines having electrical trolley haulage, every care must be taken with the negative return system, since good track bonding is very difficult to maintain. If acid water of high conductivity is also present, serious electrolytic corrosion problems from stray current may arise. Due to the relatively high electrical potentials which exist in this case, there is no practical metallic material which is immune to this type of corrosion, and elimination of the stray currents themselves is the only possible solution. There may be a similar though more localized problem when direct-current welding sets are used underground.

At the Cerro de Pasco mine in Peru this difficulty was superimposed on the corrosion problems that usually occur when acid mine water is handled. Damage was also caused by an unsuspected stray current. Details of the operation at Cerro de Pasco are given here.

Galvanic and Stray Current Corrosion on Acid Mine Water Pumps at the Cerro de Pasco Mine

Cerro de Pasco mine pumping installations handle approximately 3700 gpm in order to keep the mine drained. Of the total 3700 gpm, 2500 gal are acid mine water and the remaining 1200 gal are fresh water. The water is segregated in the mine and the two pumping systems are independent of each other.

Fig. 1 indicates the flow of acid mine water from the three pumping stations on different levels. The acid water is gathered in the 52 winze beneath the 2500 level at the bottom of the mine, on the 2100 level, and on the 1200 level. Pumped from the 2525 level station at the 52 winze to the 2100 level, it flows by gravity to the 2125 level station. From the 2125 station it is pumped to the 1200 level, where it flows by gravity to the 2125 level station. From there it is pumped to the surface.

Pumping Equipment, Maintenance, and Costs: Each of the two principal pump stations, the 1225 and the 2125, was originally equipped with three sets of Worthington centrifugal volute pumps. Each set of pumps consisted of two Worthington bronze, 8-in., three-stage SD volute pumps, coupled in series. Each set was directly coupled to an 800-hp, 2300-v, three-phase, 1190-rpm motor, one pump at each end of the motor. Capacity of these pumping units was 2000 gpm against a head of 1040 ft.

The original Worthington pumping units, installed in 1926, have operated continuously and satisfactorily. According to the records the pumps showed signs of wear in 1941. In the three-year period from 1941 to 1944 the 12 pumps of the six units were brought into the Cerro shops and given a complete overhaul. Worn parts of the casings were built up by arc welding with Aerisweld bronze rod of 3/16-in. diam applied at 130 amp. After rebuilding with the welding rod the casings were machined and fitted with oversize return channels and oversize stage pieces. All oversize parts were cast in the Cerro foundry and machined in the Cerro de Pasco shops.

Reconstruction of the pumps was successful, and for the next seven years pumping costs and maintenance were normal. Late in 1951 costs began to rise and maintenance work increased. Maintenance difficulties continued in 1952 at a growing rate, when pumping costs rose sharply to a record total of $112,600. This represented an increase of 29.2 pct in the period of one year and $61,769.00, or 121 pct, more than the average for the seven-year period from 1945 to 1951, when pump operating costs were considered normal.

Causes of Pump Deterioration: Initially it was thought that development work on the lower levels of the mine, which was draining new areas in the pyrite orebody, was producing water of a lower pH. However, analysis of the acid mine water failed to reveal any radical change in the pH or composition of the water. The copper sulfate content was lower, but pH remained in the range of 2.5 to 3.0. Although a number of theories were advanced as to the origin of the pump damage observed, the actual cause of the rapid deterioration that was occurring was not isolated and identified for some time.

Preventive Measures: In April 1953, when the pump maintenance and mine drainage problem became critical, it was almost impossible to obtain more than 14 days of service from a rebuilt and repaired pump. The pumps were being repaired in the usual manner, that is, built up with Aerisweld bronze welding rod, after which the cases were ground and the internal parts fitted in.

As a further solution, therefore, interiors of the pump casings were painted with a rubber cement, *Solufix*, which is used for applying Linatex rubber to metal or other surfaces. This cement, though not a cure, did give some measure of protection and lengthened the short service period of the pumps. Other rubber cements such as neoprene cement and *Pliobond*, a Goodyear product, were also applied. Results with all these cements were about equal and relatively ineffectual.

The interior of one pump casing was sprayed with lead and that of a second casing plated with silver. Although both gave better service than uncoated cases the relief was only temporary; casing corrosion and erosion continued at an alarming rate.

To obtain some temporary relief and to inhibit suspected electrolytic action on the bronze pump cases, plugs of metal lower on the galvanic series of metals were inserted into the interiors of the pumps through the drain plugs. Plugs of zinc and

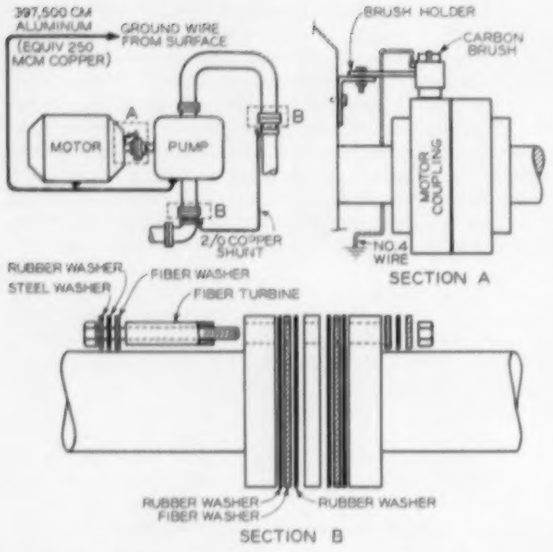


Fig. 3—Protection of pumps from stray current and galvanic action.

magnesium ⅝ in. diam by 5 in. long were used for this application. Action on the plugs was as anticipated—they disintegrated very rapidly. In some pumps the plugs lasted only 4 hr. They did give some protection, but because of the heavy consumption, replacement of the plugs as often as required was impractical.

Source of Stray Current: At this time the authors of this article directed attention to the probability that electrolytic corrosion by stray current from the mine haulage system was chiefly responsible for the trouble. Electrical readings taken on pumping equipment and pipelines confirmed the existence of stray current. The current was direct and the source was undoubtedly the 250-v dc haulage system.

Until July 1951 the motor generator sets, which convert 440-v ac to 250-v dc for the mine haulage system, had been in a centrally located station on the 1000 level, adjacent to the Lourdes shaft (Fig. 2). To comply with the new Peruvian Mining Code, in July 1951 these motor generators were moved to a new location in the compressor house outside the mine. In their former position in the mine, the generators and the mine trolley system had a good return ground through the pyrite orebody and the track bonding. When the generators were moved to the surface no negative ground line was provided for grounding back to the source of power. The possibility of stray currents and the danger inherent in their existence had apparently not been thought of, or considered, when the transfer of the converting equipment had been undertaken. It is now known that from then on this stray current began to have its deleterious effect on the mine pumps. The corrosive action was cumulative, and as corrosion progressed erosion in the pumps also increased, until in April 1953 the situation had reached the critical stage. The 2125 pump station was less affected than the 2525 and 1225 stations, which were at the extremes of the mine trolley systems and consequently had stronger stray current to contend with.

Eliminating Stray Current: As soon as the source of the stray current was located, measures were initiated to install a negative return system and ground. For this purpose a 397,500-cir mil uninsulated aluminum cable was installed from the 2525, 2125, and 1225 pump stations, through the 2100 and 1200 levels and the Lourdes shaft, to the motor generator station in the compressor house (Fig. 2). Throughout its course this cable was grounded to the pumps, the pump columns, and the air and water lines. With installation of the ground cable the stray current from the mine haulage trolley system was eliminated and corrosion from this source was stopped. This ended the emergency and pump life was then extended to an average of five months, but maintenance was still expensive, and the pumps required constant attention and repair. With the doing away of the stray current from the mine trolley system the Aerisweld bronze welding rod used to build up worn sections of the pump casings gave fair service, but the slow corrosion and subsequent erosion of the pump cases continued.

Galvanic Corrosion: Since the stray current corrosion had been identified and eliminated it was evident that the continued slower corrosion was due to some other action. All evidence then pointed to galvanic action of metals immersed in the electrolyte provided by the acid mine water. This was eventually traced to small differences in composition between the parent metal of the pump casings and the repaired areas where worn sections had been built up with welding rod. By this time these areas had become extensive.

Late in 1953 quotations and proposals were considered for modern pumping units that would be resistant to the acid water conditions and give efficient service. After considerable study, two Worthington 6-in., three-stage, type UZD-1 volute pumps were ordered. These were constructed of type 316 stainless steel with Worthite alloy rotating parts. The new units are driven by direct-coupled 800-hp motors and operate at 3550 rpm.

New Pumping Equipment: In February 1955 the first of the new units was placed in operation in the 1225 pump station. After 14 days of operation the pump became noisy. Examination revealed that Monel metal casing rings and diaphragm bushing had been installed and that these parts had been corroded. This confirmed previous suspicision of galvanic action within the pumps.

With the experience gained in the short operation of the new pump it was apparent how galvanic corrosion affected the anodic metal, monel, in this installation. Type 316 stainless steel parts were obtained to replace the former Monel parts. Since installation of these parts there has been no further galvanic corrosion, and a second all stainless steel unit has been installed. After one year of continuous service the interiors of all stainless steel pumps are spotless and show no signs of corrosion or wear.

Some of the pump discharge and suction line system is lead lined; the remainder is bronze pipe. The possibility of galvanic corrosion between those metals and the pumps has also been considered. To protect the pumps from possible corrosion from this source they have been insulated from their discharge and suction lines by special insulated flange couplings on the pipes, see Fig. 3. This insulation consists of two rubber washers and one fibre washer at the coupling. Bolt heads are also insulated by two rubber washers and one fibre washer. Bolts are encased in fibre tubing to insulate them from the flanges.

To provide a preferred path for any possible stray current that might jump the insulation on the suc-

tion and discharge lines a heavy copper wire shunt was connected from the suction line to the discharge line beyond the insulated flanges.

Evolution of Pump Corrosion: After the first pump rebuilding program, completed in 1944, galvanic corrosion in the mine pumps was slow until July 1951. This was probably due to the relatively small area of Aerisweld bronze in each pump case and also to the greater content of copper sulfate in the mine water, which inhibited the action of the weak sulfuric acid mine water as an electrolyte. Regarding electrolytes, The Worthite News,[1] a publication of the Worthington Corp., states: "Experiments in field applications have shown that the potentials can be reversed in such installations [galvanic reactions] in a matter of seconds by adding minute amounts of an oxidizing agent to the deaerated sulfuric acid, such as nitric acid, sodium chromate, copper sulfate, or ferric sulfate."

When the pumps were badly corroded by stray current after July 1951 the amount of Aerisweld bronze welding rod necessary to build up the corroded cases after that time was considerable and presented a proportionately larger area. The rough and relatively porous surface of these built-up areas provided a favorable environment for galvanic action. These factors, combined with electrolysis by stray currents, corroded the mine pumps rapidly.

A typical analysis of the acid mine waters before precipitation of the copper is as follows:

Copper content	0.30 gpl
Free sulfuric acid content	2.5 gpl
Ferric iron content	4.0 gpl

Other constituents of the mine water are present in minor quantities and are not important.

Conclusions: Stray currents that can cause serious corrosion are always direct current and are commonly encountered in mines using direct current haulage systems. No test for the absence or presence of stray current should be depended on. A test might indicate no stray current one time, but a ground could occur and the resulting current could cause much damage before it was discovered. All installations should be adequately protected from the time of installation and checks of their effectiveness should be made at regular and frequent intervals. Meter readings can be taken between the pump and the isolated pump column, with the suspected source of current first on and then off, and any variation in reading noted.

Acid mine waters can be very good electrolytes and provide a favorable environment for galvanic corrosion. Insulating the pump adequately from stray currents also insulates it from the possibility of galvanic action from adjoining and connected equipment. Galvanic action within the pump cannot be controlled; equipment must be entirely of similar metals if such corrosion is to be avoided.

There is no doubt that many pumping installations have suffered severely from the corrosive action of stray and galvanic currents. It is hoped that this discussion will be of value to others operating pumps in similar environments.

Reference

[1] Galvanic and Stray Current Corrosion. *The Worthite News*, May 1952, vol. 4, no. 3.

Discussion on this paper (2 copies) sent to AIME by Sept. 30, 1956, will appear in Mining Engineering and in AIME *Transactions*, vol. 205, 1956.

A Method of Preparing Closely Sized Micron and Submicron Fractions

by R. W. Smith and R. J. Charles

Fractions of glass particles in the size range 0.5 to 5.0 μ were prepared by an elutriator that operates in a centrifugal field. Although mean sizes of commercially graded abrasive powders were ten times greater than those of samples prepared by the elutriator, frequency size plots for elutriator samples compared favorably. Efficiency of separation was low and amounts of material recovered by the elutriator were small, but the method should find use in preparation of small amounts of sized materials for laboratory investigations.

R. W. SMITH, Junior Member AIME, Research Assistant, Dept. of Metallurgy, Massachusetts Institute of Technology, is presently with Portland Cement Ass'n., Chicago. R. J. CHARLES, Junior Member AIME, formerly Assistant Professor, Dept. of Metallurgy, Massachusetts Institute of Technology, is Research Associate, Ceramic Studies Section, General Electric Co., Schenectady, N. Y.

TP 4261B. Manuscript, Jan. 31, 1956.

STUDY of light adsorption, reaction rates, electrophoresis, particle packing, and corrosion is hindered by lack of a suitable method of preparing small amounts of closely sized materials in the micron and submicron range. Most fractionation methods depend on some form of particle movement through a viscous media in which velocity of a par-

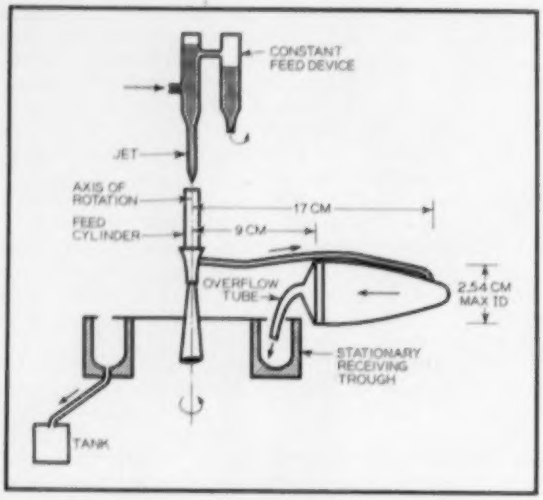


Fig. 1—The centrifugal elutriator.

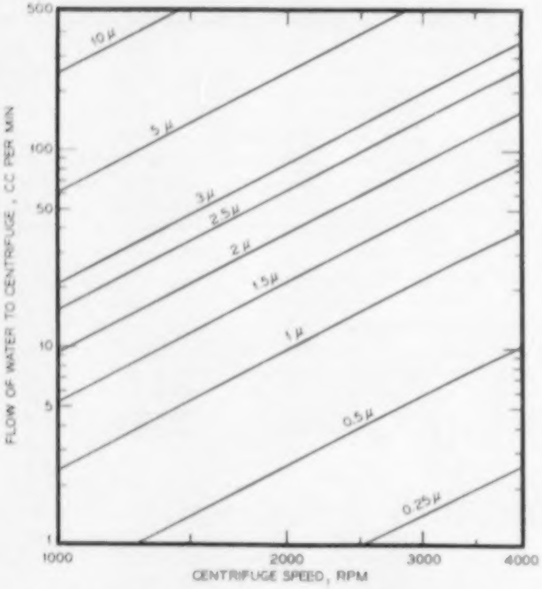


Fig. 2—Separating size as a function of rotational speed and rate of flow to centrifuge.

ticle, relative to the media, is controlled by particle size. Fractionation by settling at particle sizes of 0.1 to 5.0 μ is best by many difficulties, chiefly:

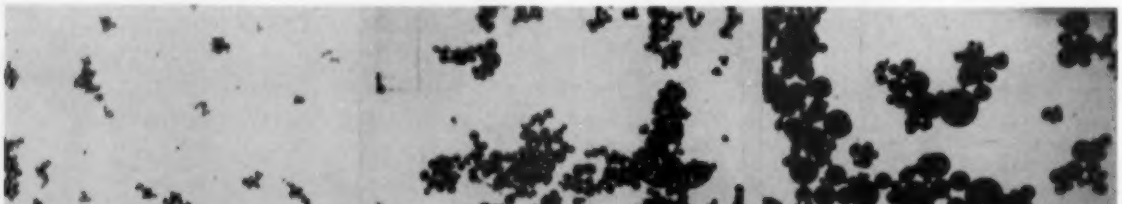
1) Thermal currents and Brownian movement result in disordered particle motions at velocities comparable to settling velocities of the particles.

2) The resolution obtained with ordinary light microscope techniques is not sufficient for satisfactory analysis of results of a separating operation.

3) Flocculation prevents particles from acting as individuals and the settling characteristics of the particles are altered.

In an attempt to develop a fractionating method applicable to the 0.1 to 5.0 μ range, a separating device employing elutriation in a centrifugal field has been studied. A number of steps were taken to obviate the difficulties listed above. Relatively high particle settling velocities were obtained by employing high centrifugal force fields, minimizing the effects of Brownian motion. The electron microscope was used for visual observation of samples, and thus resolutions many times smaller than those possible with light microscopes were obtainable. Because high settling velocities permitted rapid separations, the time in which flocculation could take place was short. Further, washing and agitation of particles that formed into flocs was possible during the complete separation cycle.

Description of Apparatus: Fig. 1 is a diagram of the centrifugal elutriator. A dilute water suspension of the particles to be fractionated enters the feed cylinder from a controlled flow jet. The suspension flows through the connecting tube and the centrifuge bottle under the action of a static head and a centrifugal force. Flow of water through the bottle carries particles finer than a critical size over the lip of the bottle into the stationary receiving trough. Coarser particles remain in the centrifuge bottle. Flow of water and speed of rotation of the centrifuge can be adjusted so that a particle size separation can have any convenient value. Approximate values for speed of rotation and water flow for a specific size separation can be calculated from a modification of Stokes' law[1] for a stationary particle in a vertically moving fluid under the action of normal gravity.



0.5 to 1.0 μ sized fraction | **1 to 2 μ sized fraction** | **2 to 5 μ sized fraction**

Fig. 3—Electron micrographs of sized fractions prepared by the centrifugal elutriator.

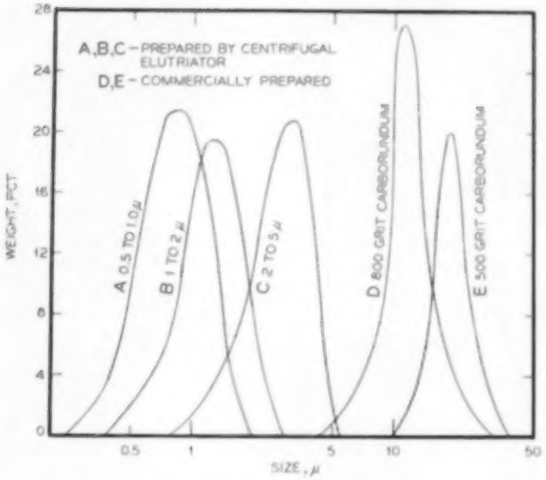


Fig. 4—Frequency plots of sized fractions.

Stokes' law is as follows:

Upward viscous flow force on particle = Downward force of gravity on particle

$$6\pi r\eta v = 4/3\pi r^3(\rho_s \rho_1)g \qquad [1]$$

where η = coefficient of viscosity of fluid, v = critical fluid velocity, r = particle radius; ρ_s = density of particle, ρ_1 = density of fluid, and g = acceleration of gravity.

For a particle in the bottle of the centrifugal elutriator the force acting radially inward corresponds to the viscous flow force. The radially acting outward force, corresponding to force of gravity in Eq. 1, depends on rotational speed and direction of the bottle of the centrifuge and is given by the expression $4/3\pi r^3(\rho_s - \rho_1)x\omega^2$, where x is the particle distance from the center of the centrifuge and ω is the angular velocity of the centrifuge. Therefore, for a particle in equilibrium in the centrifuge the modified form of Stokes' law becomes

$$6\pi r\eta v = 4/3\pi r^3(\rho_s - \rho_1)x\omega^2 \qquad [2]$$

or for a given separating diameter and for a specific centrifuge,

$$d_s = \sqrt{18\,V\eta/Ax(2\pi N)^2\,(\rho_s - \rho_1)} \qquad [3]$$

where d_s = separating size in centimeters, A = cross-sectional area of centrifuge bottle at point of discharge in cm², V = volumetric rate of flow in cm³ per sec, x = distance from center of rotation to point of discharge of the centrifuge in centimeters, and N = rotational speed in revolutions per second.

Eq. 3 has been solved for the centrifuge under investigation and for various values of separating size. Solutions are given graphically in Fig. 2.

In simple elutriation the velocity of fluid required to keep a particle in equilibrium is proportional to acceleration of gravity, g, while in the centrifugal elutriator this velocity is proportional to the centrifugal acceleration at the particle position, $x\omega^2$. Thus in the centrifugal elutriator the velocity of fluid moving radially inward necessary to keep a particle in equilibrium is greater by the ratio $x\omega^2{:}g$ than the flow necessary in a simple elutriator. The ratio $x\omega^2{:}g$ may be the order of 10 to 5000 for practical design purposes.

Since the velocity of the moving fluid controls the rate at which fine material may be removed from an elutriator, it is apparent that the centrifugal elutriator should effect a separation of fine material much quicker than a simple elutriator. Also, since the elutriator forces acting on the finer particles are proportionally greater, it should be possible to obtain finer size separations.

Materials Used: Spherical glass beads were used as feed material in the elutriator tests in order to simplify particle counting procedure and to satisfy the conditions required by Stokes' law. The beads were made by crushing plates of glass in a jaw crusher, grinding the glass in a small Abbe porcelain mill, and then shooting the glass particles into an acetylene flame to make them spherical. After spheroidizing, the sample was run through an International Chemical centrifuge with a basket attachment in order to obtain a sample that contained only a very few particles larger than 10 μ.

Attempts were made to prepare dispersed suspensions of the glass beads in ordinary distilled water and in conductivity water. Those suspensions prepared with distilled water tended to flocculate and the particles settled out after standing several hours, while those prepared with conductivity water remained in suspension for weeks. As a result of this finding the feed suspension used in all tests was prepared in conductivity water.

Experimental Results: *Size Fractionations:* Tests were run with the centrifugal elutriator to obtain sized fractions between 5 and 2 μ, between 2 and 1 μ, and between 1 and 0.5 μ. To obtain these fractions a size separation was made of the feed material at the maximum desired size, taking the overflow for feed to the elutriator and making a size separation

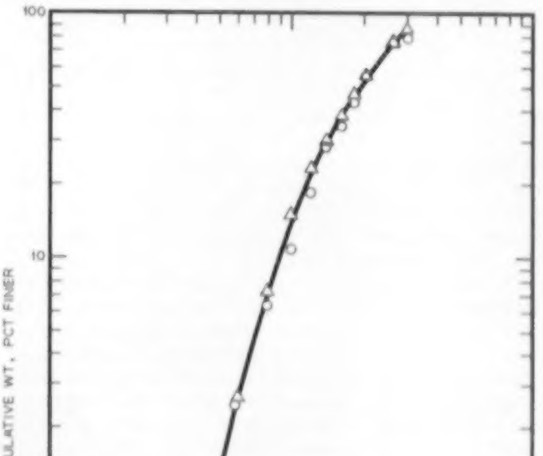
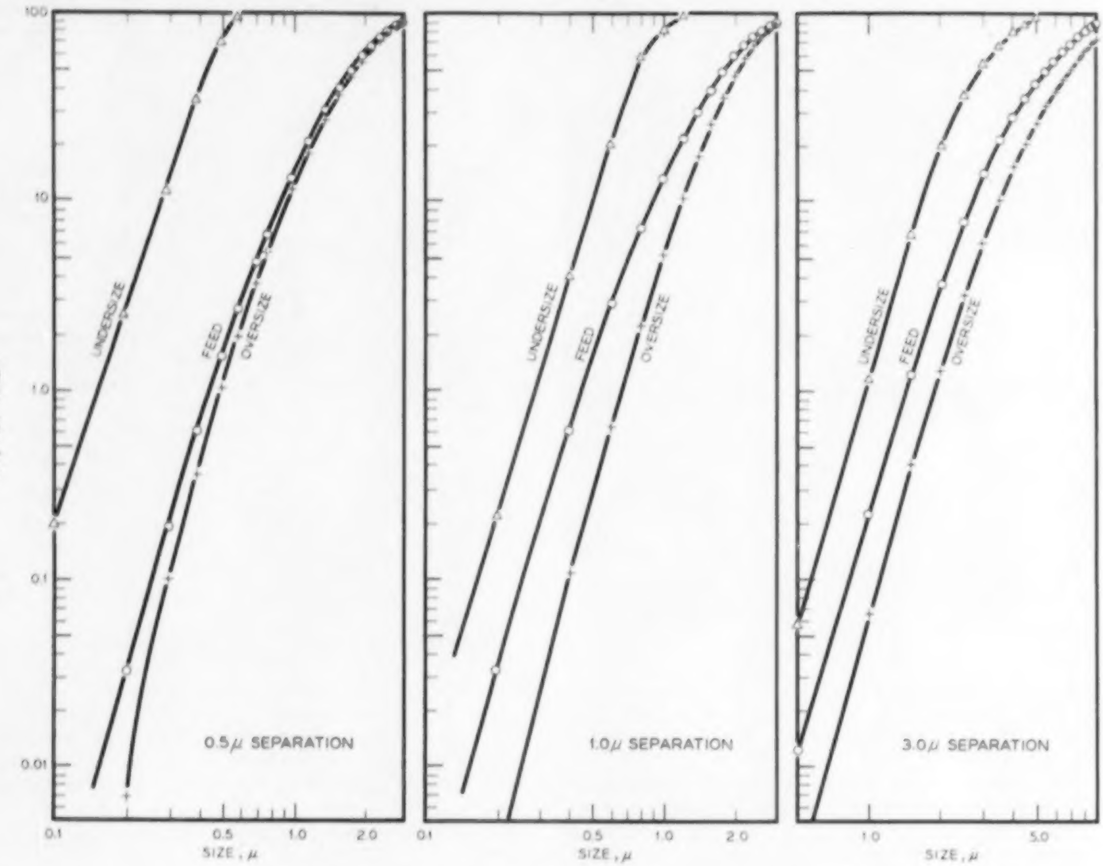


Fig. 5—Comparison of air pulse and water suspension methods of sample preparation.



Figs. 6, 7, and 8—Size analyses of products from elutriator separations.

at the minimum desired size. The material remaining in the centrifuge bottle from the last separation was the desired size fraction. Conditions for operating the centrifuge for various size separations were obtained from the graph, Fig. 2.

Electron micrographs were made of the fractionated products from which particle size counts could be made. Fig. 3 shows mosaics of electron micrographs of three size fractions obtained, and Fig. 4 shows frequency plots for the particles in the fractionated samples. Included in Fig. 4 are frequency plots of graded carborundum powders, prepared commercially by Carborundum Corp. and considered examples of good fractionation. Frequency plots of the materials prepared by the centrifugal elutriator compare very favorably with those of the graded carborundum powders, even though the mean sizes of the latter graded samples were ten times greater than those of the samples prepared by the elutriator.

Unfortunately the amounts of material recovered in the fractionations by the centrifugal elutriator were small. In general, for a test of 1 g of material in 1 liter of water, between 20 and 50 mg of fractionated material would be recovered. To estimate recoveries obtained in the size fractionations and to determine whether the centrifugal elutriator could be applied to the quantitative measurement of size distributions in the micron range, a number of separation tests were made in which the size distributions of feed, overflow, and material retained in the centrifuge bottle were measured.

Size Separations: By means of sedimentation-decantation of portions of the original material prepared in the flame spheroidizer, a sample containing spherical glass particles less than 5 μ and a sample containing glass particles less than 10 μ were prepared. These two samples were used as feed to the centrifugal elutriator for various size separation tests.

To check reproducibility of the particle size counting techniques and of sample preparation for the electron microscope, size distribution curves for the -5 μ feed sample were obtained from micrographs of specimen grids prepared in two dissimilar ways. It was believed that if the size distribution curves obtained were similar, confidence in the methods of preparation would be warranted. One method of specimen grid preparation was to allow a drop of a dilute water suspension of the material to dry on the grid. The other method was to distribute a small amount of the dry sample, by means of an air pulse, at the top of a closed tube and allow the dust particles to settle on a specimen grid placed at the bottom of the tube. Electron micrographs of a large number of different fields of the specimens were made and about 1000 particle counts were made for each specimen. Fig. 5 shows size distribution curves obtained for the -5 μ sample. The resulting good check indicated that both sample preparation and

particle counting techniques would be satisfactory for the size separation tests.

From the graph given in Fig. 2 flow rates and centrifuge speeds were selected so that size separations at approximately 0.5, 1.0, and 3.0 μ could be made. In each case 1 liter of suspension containing about 1 g of feed material was passed once through the elutriator. After the suspension had been run through the elutriator, about ½ liter of wash water was passed through at the same feed rate as the previous suspension. Products from the separation were collected, samples prepared and examined, and particle counts made. Figs. 6, 7, and 8 illustrate results of these tests and show for each test that, although a size separation took place near the predicted separating size, considerable material finer than separating size remained in the oversize material. Recovery graphs, Fig. 9, show how much of each size fraction in the feed reported in each of the elutriator products. Actual separating size for a test is given by the intersection of recovery curves for the test. The intersection occurs where 50 pct of the particles of a certain size report as undersize and 50 pct as oversize. The steeper the slopes of a pair of curves at their intersection, the better the separation. If the elutriator were 100 pct efficient, the undersize curve would be a straight line at 100 pct from a minimum size to the separating size, and the oversize curve would be a straight line at 100 pct from a maximum size to the separating size.

Fig. 9 shows, as in the previous figures, that considerable undersize material is left in the oversize fraction after the separation. For the results shown only about 80 to 85 pct of the particles of a size one half of the separating size were removed in the undersize product. The curves show, however, that although fines were left in the oversize product little material greater than separating size reported to the undersize product. These results indicate that if flocculation of the fine particles around larger ones could be prevented, relatively sharp separations might be obtained in the elutriator.

The elutriator may be considered a type of classifier and the efficiency of classification calculated by means of Taggart's formula[2] as follows:

$$E = \frac{10{,}000\,(c-f)\,(f-t)}{f\,(100-f)\,(c-t)} \qquad [4]$$

where E = classification efficiency, f = percent of material less than separating size in feed, c = percent of material less than separating size in overflow, and t = percent of material less than separating size in underflow. Results of the application of this formula to the above separating tests in the elutriator are given in Table I.

Table I. Classification Efficiency of the Centrifugal Elutriator

Test	Separating Size, μ	Classifier Efficiency, Pct
A	0.55	60
B	0.95	70
C	3.2	54

Efficiencies given in Table I are of the order of magnitude achieved in commercial classification installations, but they are not high enough to permit measuring size distributions by a method employing classification at the above efficiencies. For example, determination of size distributions by careful laboratory screening would, on the basis of the above

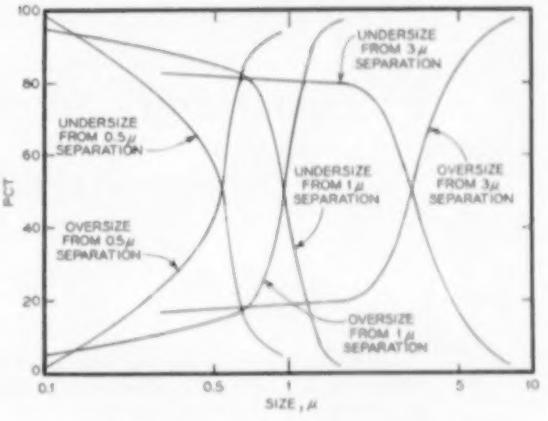


Fig. 9—Recovery curves for elutriator separations.

formula, give size separations at nearly 100 pct efficiency, and any size separation technique to be used for determination of size distributions should have an efficiency of separation of 80 pct or better.

Summary and Conclusions

An elutriator in which a centrifugal action was incorporated has been constructed and tested for size fractionations and size separations in the micron and submicron range. Small amounts of well fractionated material of 0.5 to 5.0 μ size were prepared with the elutriator. Such samples may be of considerable value in physico-chemical studies where fineness and closeness of size is an important factor.

Separation tests with the elutriator show that efficiency of classification is of the same order as that of laboratory and commercial classification units. The relatively low efficiencies obtained were attributed mainly to the difficulty of maintaining the material to be separated in a satisfactorily dispersed state. Higher efficiencies of separation than those obtained throughout the tests would be necessary if the centrifugal elutriator were to be used to determine size distributions in the micron and submicron range.

Acknowledgments

The authors wish to acknowledge the assistance given them by their associates at the Massachusetts Institute of Technology. They especially thank A. M. Gaudin for his suggestions and interest in the investigation. The work was carried out under the Comminution Research Program of the Dept. of Metallurgy at Massachusetts Institute of Technology. Initial sponsorship of the Comminution Research Program was received from the Engineering Foundation. The current program is sponsored by the Engineering Foundation, the American Iron and Steel Institute, the U. S. Atomic Energy Commission, Aerofall Mills, Allis-Chalmers Mfg Co., Bethlehem Steel Co., Kennecott Copper Corp., National Gypsum Co., and Union Carbide and Carbon Corp.

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Discussion of this paper sent (2 copies) to AIME before Oct. 31, 1956, will appear in MINING ENGINEERING and in AIME *Transactions*, Vol. 206, 1956.

Flocculation of Mineral Suspensions With Coprecipitated Polyelectrolytes

by Milton E. Wadsworth and Ivan B. Cutler

Coprecipitation of anionic and cationic polyelectrolytes has been applied to flocculation of several mineral systems. Results obtained in a study of the flocculation of kaolinite and hematite suspensions of polycationic and polyanionic electrolytes are presented. Greatly increased settling rates were observed following precipitation of positive and negative polyelectrolytes on the surface of finely divided minerals in aqueous suspension. The ratios of polycationic to polyanionic electrolytes required to produce maximum sedimentation have been shown to correspond closely with the equivalence points obtained by light scattering studies of systems containing the positive and negative polyelectrolytes by themselves.

DISPERSION of colloids has been of interest to surface chemists for many years. Flocculation studies have been employed to evaluate the limits of colloid stability. In water suspensions, colloids become unstable and flocculate when the ζ potential, the potential of the kinetic solvation sheath, falls to a value at which van der Waals forces may act to draw the particles together. This may happen through an adjustment of the pH of the suspension or by addition of a salt. Optimum conditions for rapid formation of large flocs are found in the region of minimum ζ potential.

In addition to these well known considerations, colloids in water suspensions are known to be flocculated by certain large organic macromolecules. These polyelectrolytes in some cases minimize the ζ potential and in other instances increase the attractive forces by supplying sites for hydrogen bonding.[1]

Use of organic polyelectrolytes in flocculation of mineral colloids has increased rapidly in recent years. These materials are now recognized as indispensable aids to fluid-solid separations in many extractive metallurgical operations. They have been found to increase both the settling rate in thickeners and the filtration rate of filters. In the elucidation of the characteristics of these organic reagents as flocculants in this laboratory, it was discovered that interaction of certain polyelectrolytes had a surprisingly good effect on flocculation of mineral colloids.

Experimental Procedure: The anionic flocculants used in this study were Lytron 886 and 887, produced by Monsanto Chemical Co. Both reagents are copolymers of vinyl acetate and maleic anhydride. Lime is added to Lytron 886, whereas Lytron 887 is all organic. These reagents possess two carboxyl groups for each acetate group and are therefore anionic in character. The cationic reagents used were the Peter Cooper Co. 1-X and 2-X glues. The structures are not definitely known, but the reagents are amines and are cationic in character. The glues were prepared in the chrome-alum form. Both types of reagents may be classified as polyelectrolytes in that they are high molecular weight polymers and ionize in water.

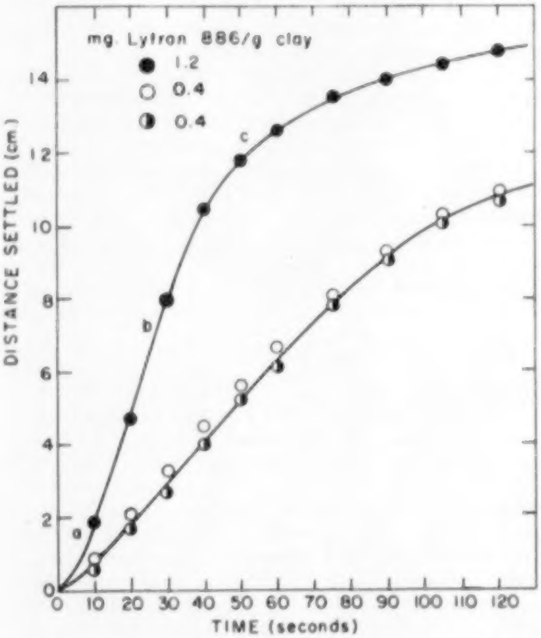

Fig. 1—Typical settling curve for a 2 pct kaolinite pulp.

All data presented are in terms of sedimentation rate, measured in 250-ml glass-stoppered graduated cylinders. With suitable precautions such measurements are fairly reproducible and provide a sensitive means for selecting important parameters such as pH, reagent concentration, and floc size and density.[2] Agitation was standardized with five complete end over end cycles of the suspensions in the stoppered graduated cylinders.

M. E. WADSWORTH, Member AIME, and I. B. CUTLER are Associate Professors in the Departments of Metallurgy and Ceramics, respectively, at the University of Utah, Salt Lake City.

TP 4264BD. Manuscript, Aug. 26, 1955. Chicago Meeting, February 1955.

Mineral systems investigated were the clay mineral kaolinite from Florida (Edgar Plastic Kaolin Co.) and specular hematite (Cleveland Cliffs Iron Co.). The clay was acid washed with HCl at a pH of 2, followed by successive decantations with distilled water until the pH was between 4.5 and 5.0. Clay suspensions, 2 pct by weight, provided optimum settling conditions. The specular hematite (−8 mesh) was ground for 20 min in an 8-in. steel laboratory ball mill using a 10-kg steel ball charge. The hematite ore contained approximately 40 pct iron and consisted predominantly of hematite and a siliceous gangue. Pulp densities of 15 pct by weight were found to provide optimum settling conditions.

The mutual interaction of the polyanionic and polycationic flocculants was investigated by a method similar to that used by Fuoss and Sadek.[8] Reflectance of light from a suspension of the coprecipitated polyelectrolytes was measured with a diffuse reflectance attachment on a Beckman DU spectrophotometer. The Peter Cooper 1-X glue at a concentration of 5 gpl was used as the reflectance standard for all tests. Scattering was measured at 850 mμ wave length with a constant slit opening of 2 mm.

Experimental Results and Discussion: Fig. 1 plots a typical sedimentation curve for a flocculated mineral suspension. Since time is required for flocs to grow to full size and for eddy currents resulting from agitation to subside, an induction period (*a*) is observed. With full-size flocs, sedimentation occurs (*b*) as constant rate until the flocs begin to compress each other at c. The lower curve represents two separate determinations at 2 mg Lytron 886 in 250 ml of 2 pct kaolinite pulp. Several factors affect the sedimentation curve. Concentration of the mineral in suspension greatly influences the straight line portion of the curve. If too concentrated, the flocculated mineral suspension will go into compression almost immediately. If too dilute, the mineral suspension will have an extended induction period and will show a diffuse interface between the flocs and the clear supernatent liquid above. The slope of the linear portion of the settling curve at *b* is taken as the settling rate.

Figs. 2 and 3 illustrate the effect of Lytron 886 by itself as a flocculant for kaolinite and hematite. The maximum in the curve observed in the case of kaolinite, Fig. 2, is typical of results obtained at relatively high flocculant concentration. The curve for hematite, Fig. 3, does not drop off again, but in this case there was a difference of approximately 300 times in the amount of flocculant present per unit weight of mineral. Precipitation of flocculants at the mineral surface was observed to increase greatly the sedimentation rate in several mineral systems. Included here are results obtained on kaolinite and hematite. Figs. 4 and 5 illustrate sedimentation rate vs concentration of polycation (Peter Cooper 1-X, chrome glue). In each case a constant amount of the polyanionic reagent (Lytron 886) was added first and allowed to come to equilibrium with the mineral surface before the variable amount of polycation was added.

The adsorption of anionic reagents has been suggested by Ruehrwein and Ward[4] to be a result of anion exchange. These authors have also demonstrated mechanical bridging of the flocculant between the mineral particles. French et al.[1] have demonstrated the presence of hydrogen bonding in such flocculated systems by means of infrared spectroscopy. This is probably important in forming

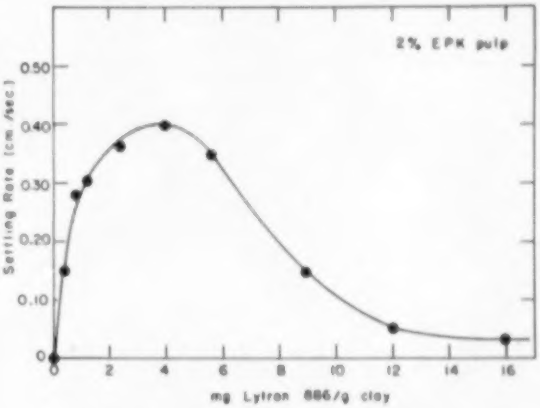

Fig. 2—Settling rate vs concentration of polyanionic electrolyte.

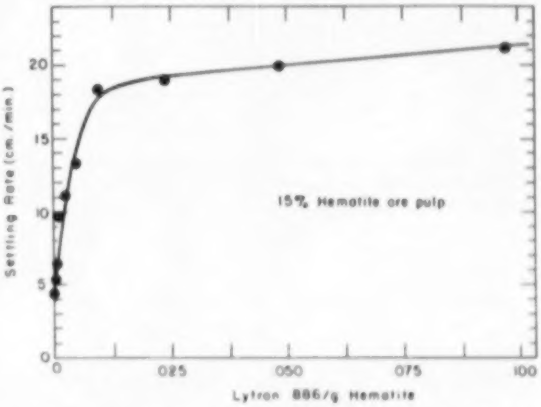

Fig. 3—Settling rate vs concentration of polyanionic electrolyte.

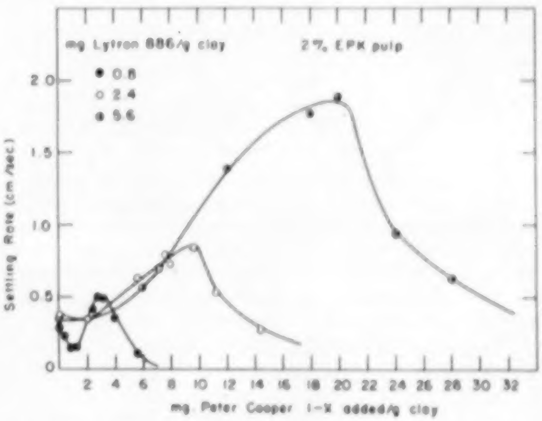

Fig. 4—Effect of surface coprecipitation of polyanionic and polycationic electrolytes, the polyanionic adsorbed first on kaolinite.

interparticle bridging and perhaps contributes to the particle flocculant interaction. Coprecipitation of polyanions with polycations has been observed by Fuoss and Sadek,[8] Deuel et al.,[3] Ruehrwein and Ward,[4] and others. Studies reported here indicate this may also be accomplished on the surface of minerals by adding one of the polyelectrolytes first. Adsorption of a polyanionic reagent on the surface

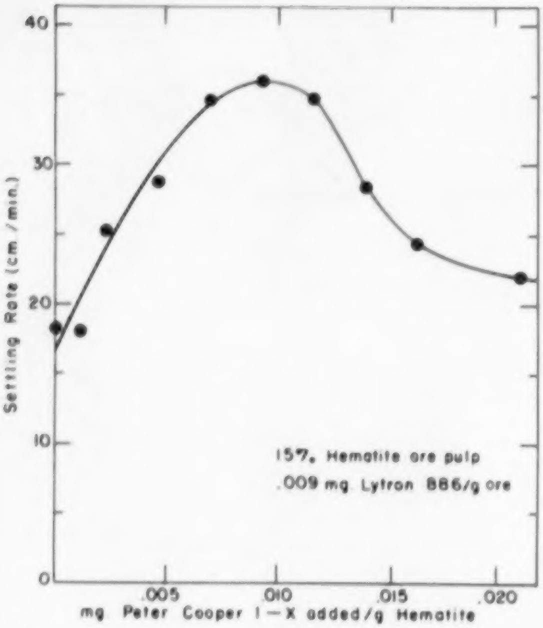

Fig. 5—Effect of surface coprecipitation of polyanionic and polycationic electrolytes, the polyanionic adsorbed first on hematite.

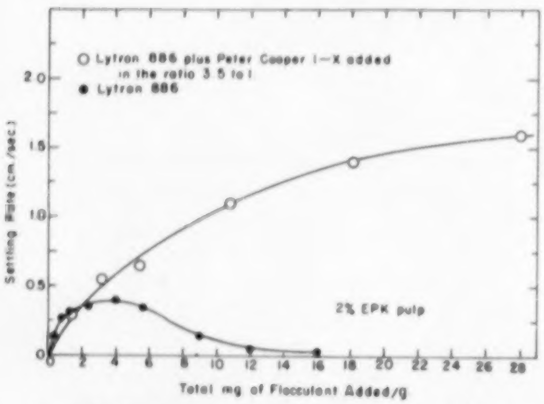

Fig. 6—Settling rate vs concentration of flocculant added, comparing combination of polyanionic and polycationic with polyanionic by itself for Lytron 886 and Peter Cooper 1-X.

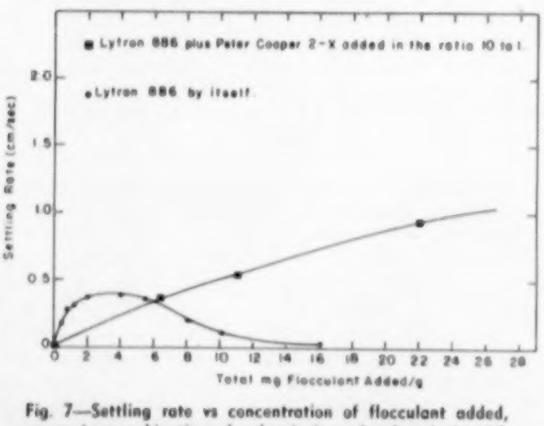

Fig. 7—Settling rate vs concentration of flocculant added, comparing combination of polyanionic and polycationic with polyanionic by itself for Lytron and Peter Cooper 2-X.

of a mineral increases subsequent mineral-polycation interaction, the reaction now being predominantly between the two oppositely charged polyelectrolytes. The improved flocculation observed may perhaps be attributed to the possibility that the hydrogen bond linkage causing bridging of the anionic flocculant between particles by itself may be replaced by a much stronger positive-negative charge interaction associated with the surface coprecipitate. Large stable flocs may be formed by this means.

The ratio of polycationic to polyanionic flocculant necessary to provide maximum sedimentation was 3.5:1 for kaolinite and 1:1 for hematite. Settling rates continue to increase as the flocculants are added in these ratios up to very large concentrations, suggesting increased interparticle bridging. In these systems the precaution of adding one reagent to the mineral suspension before the other must be observed. If the polyanionic and polycationic flocculants are added together they will coprecipitate and little or no flocculation will result. Fig. 6 illustrates the results obtained with kaolinite in which the ratio of polycationic to polyanionic flocculation was maintained constant. The lower curve represents the sedimentation rate of kaolinite vs concentration of Lytron 886 added by itself. Similar curves are plotted in Figs. 7 and 8. Fig. 7 is a plot of settling rate vs total flocculant added for Lytron 886 and Peter Cooper 2-X glue. This glue is a protein similar to 1-X but lower in nitrogen content. The equivalence point was found to be 10:1 for the 2-X glue compared to 3.5:1 for the 1-X glue. The Peter Cooper 1-X glue was found to be a more effective flocculant than the 2-X form. Fig. 8 is a similar plot for Lytron 887 and Peter Cooper 1-X glue. Again a very marked increase in settling rate was obtained. The equivalence point in this instance was 4.2:1.

The order in which the reagents are added is particularly important. In the pH2 to 7 range for kaolinite it was found necessary to adsorb the polyanionic reagent first and add the polycationic reagent last. On microcline (feldspar) the reversed order (polycationic first) was necessary to flocculate the suspension at neutral pH. It appears, therefore, if the adjusted pH, and consequently the surface charge, is such that the polyanion can adsorb, the best effects are obtained by adding it first. On the other hand, at pH values of high cation exchange the reversed order is most effective. This could not be clearly demonstrated for kaolinite at high pH, however, because of the cloudy overflow which could not be cleared. To obtain the improved settling rates illustrated in Figs. 4 and 5, any mineral-polyelectrolyte system must have the following characteristics: 1) there must be adsorption by hydrogen bonding, ion exchange, or ion pair adsorption of either an anionic or cationic polyelectrolyte on the mineral surface and 2) the counter polyelectrolyte must coprecipitate with the adsorbed polyelectrolyte. The importance of the second characteristic may be seen in the following study of the coprecipitation of anionic and cationic reagents used in sedimentation studies reported in Figs. 4 and 5.

Precipitation of polyelectrolytes in the absence of mineral colloids resulted in large increases in light scattering. Light scattering was measured for several series of solutions made up to constant volume and consisting of fixed amounts of one polyelectrolyte and variable amounts of the counter polyelec-

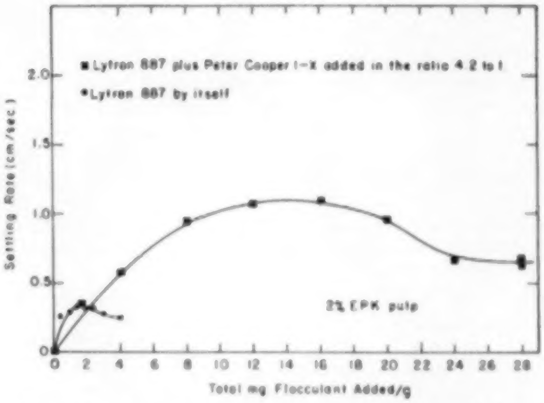

Fig. 8—Settling rate vs concentration of flocculant added, comparing combination of polyanionic and polycationic with polyanionic by itself for Lytron 887 and Peter Cooper 1-X.

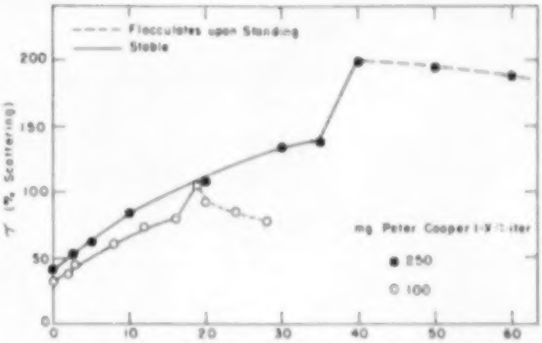

Fig. 10—Light scattering curves for coprecipitation of Lytron 886 and Peter Cooper 1-X chrome glue. Peter Cooper 1-X constant.

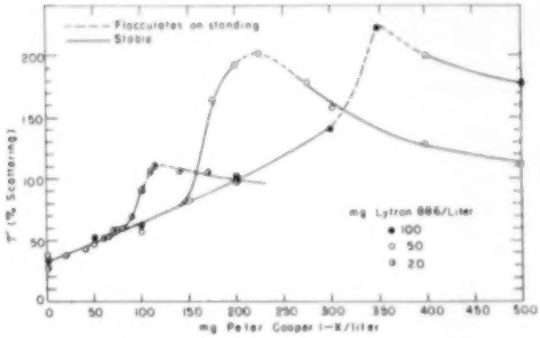

Fig. 9—Light scattering curves for coprecipitation of Lytron 886 with Peter Cooper 1-X chrome glue. Lytron 886 constant.

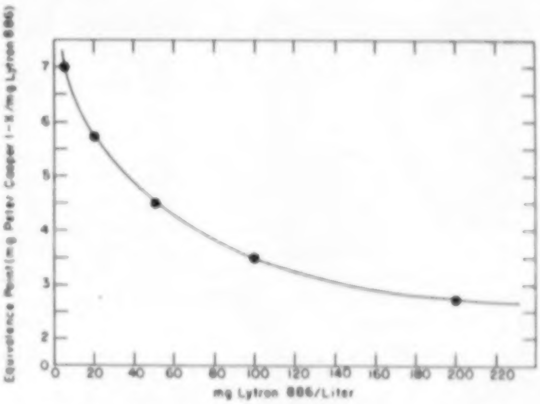

Fig. 11—Equivalence points between Peter Cooper 1-X chrome glue and Lytron 886 for various concentrations of Lytron 886.

trolyte. These *titration* curves at constant volume may be seen in Figs. 9 and 10. For each titration series in Fig. 9 the polyanionic concentration (Lytron 886) was held constant and in Fig. 10 the polycationic concentration (Peter Cooper 1-X) remained constant for any one series. Near the equivalence point the ζ potential is sufficiently low to allow flocculation of the coprecipitate. This has been observed previously by Deuel et al.[5] Flocculation of the coprecipitate is shown in Figs. 9 and 10 as the dotted sections of the curves. The diffuse reflectance measurements in this region yielded values of percent light scattering which decreased with increasing time. The similarity between the settling rate curves of Figs. 4 and 5 and the reflectance curves of Figs. 9 and 10 is clearly a result of the coprecipitation effect.

Fig. 11 illustrates the fact that the equivalence point as determined by light scattering varies with the concentration of polyelectrolytes present. At low polyanion concentration the equivalence point is large and at high polyanion concentration the equivalence point is appreciably lowered. This lowering at high concentration suggests micelle formation or a configuration of the polyanion in which many of the active groups are not available to the polycation.

Summary

Coprecipitation of adsorbed polyanions with polycations offers advantages over adsorbed polyanions or polycations alone by markedly increasing sedimentation rates of mineral suspensions.

Reflectance studies of coprecipitation of polyanionic and polycationic flocculants in the absence of the mineral suspension closely parallel results obtained by surface coprecipitation in the presence of the mineral suspension as detected by the variation in settling rate. The equivalence point of coprecipitation varies with the concentration of the polyelectrolytes present.

Acknowledgment

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Abstract

Purification of $GeCl_4$ by Extraction with HCl and Chlorine

by H. C. Theuerer

(JOURNAL OF METALS, page 688, May 1956; AIME Trans., vol. 206)

GeCl may be purified by extraction with HCl and chlorine. The process is as effective for the removal of $AsCl_3$ as the more cumbersome distillation methods usually used for this purpose. The extraction process may be used in a batch process or can be adapted to continuous extraction methods.

Technical Note

Measuring Zeta Potentials by Streaming Potential Techniques

by D. W. Fuerstenau

MEASUREMENT of zeta potentials is a useful tool to study the surface chemistry of minerals under flotation conditions.[1,2] Because there is continued interest in this approach, the apparatus for obtaining zeta potentials of nonconducting solids by the streaming potential method is outlined here.

Fig. 1 illustrates the streaming potential apparatus.* The streaming potential cell or plug consists of two 24/40 standard ground joints (4) joined with a piece of pyrex tubing 60 mm long and 12 mm in diam (5). The electrodes are made of bright platinum disks 19 mm in diam and 1 mm thick through which 0.5-mm holes have been drilled (6). To the surface of each is welded a piece of 80-mesh platinum gauze. Each electrode is permanently mounted on the ends of the inner parts of the two standard joints by means of a platinum wire (7) which connects it to the tungsten seal at the end of the cell (8). For ease in cleaning and handling the apparatus, the streaming cell is fastened to the 500-ml reservoir flasks (1) by means of two 18/9 ball and socket joints (2). This particular arrangement permits passage of the solution in either direction through the plug of particles. Flow of solution can be stopped by a stopcock (3). One of the reservoir flasks has a large opening to permit insertion of either a thermometer or a pair of electrodes for measuring pH of solutions within the system. In making the experiments, the plug is filled with 48 to 65-mesh particles, but a layer of 28 to 35-mesh particles is placed at each electrode to prevent any of the finer particles from passing through holes in the electrodes.

* This is essentially the apparatus described in the author's doctoral thesis[1] but slight modifications have been made on it since that time.

The assembled apparatus is shown schematically in Fig. 2. To eliminate CO_2 from the solutions, all experiments are conducted in a nitrogen atmosphere. Nitrogen, used to drive solutions through the plug, is passed through a bottle of concentrated KOH solution to remove CO_2 (9). A 9-liter ballast reservoir (10) is used to maintain a more nearly uniform pressure. A series of stopcocks controls the direction of flow nitrogen to the flasks (11). Tubes of ascarite prevent backflow of CO_2 into the system (12). Driving pressure, which can be set at any desired value, is measured with either a water manometer (13) or a mercury manometer (14). Reservoir flasks have side arms for making pressure corrections for the difference in water levels in the flasks.

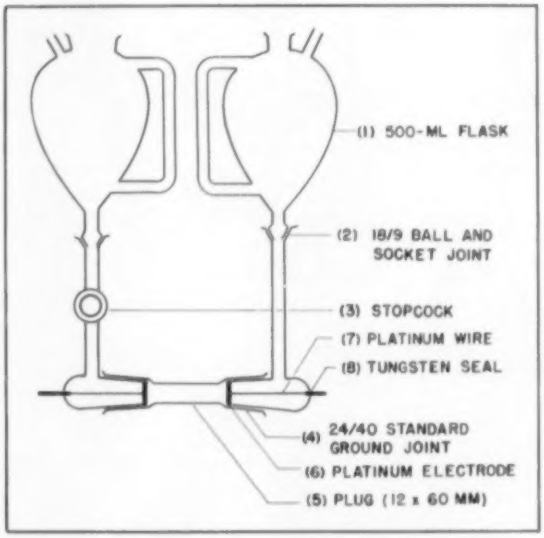

Fig. 1—Diagram of the streaming potential cell.

Streaming potentials are measured by the circuit illustrated in Fig. 2. The electrodes from the plug are connected through mercury wells (15) to a reversing switch (16), which reverses the polarity of the electrodes depending on the direction of flow of solution through the plug. The streaming potential is measured with a Leeds and Northrup type K2 potentiometer (17). Proper choice of null instrument is important because Eq. 1 assumes that the current which escapes through the measuring instruments is negligible. An ordinary galvanometer cannot be used to determine the null point because

D. W. FUERSTENAU, Junior Member AIME, formerly Assistant Professor of Mineral Engineering, Massachusetts Institute of Technology, is with the Metals Research Laboratories, Electro Metallurgical Co., Niagara Falls, N. Y.

TN 340B. Manuscript, Sept. 14, 1955.

it permits discharge of the electrodes to a significant extent. Therefore the null point is determined by measuring the potential across a wax-coated 10^{12}-ohm resistance (18) placed in series with the potentiometer and plug. The streaming potential is exactly balanced when the potential across the 10^{12}-ohm resistance is at zero on the Applied Physics Corp. vibrating reed electrometer (19). To extend the range of the potentiometer, several calibrated 1½-v batteries (20) can be placed in series with the potentiometer by means of switches (21, 22). Fig. 3 shows that the streaming potential, E, is directly proportional to the pressure difference, P, up to at least 46 cm of mercury and that it is independent of direction of flow.

The specific conductance of solutions inside the plug can be determined by one of two methods: 1) a 1000-cycle ac bridge for resistances less than one megohm and 2) a dc bridge for resistances greater than one megohm.

The 1000-cycle ac bridge setup includes a General Radio type 650-A impedance bridge in conjunction with an audio amplifier and oscilloscope to determine the null point. The reactance component is balanced out by means of a variable air capacitor placed across one of the bridge arms.

Fig. 4 illustrates the dc bridge used to measure high resistances. A standard potential of about 1.5 v (B) is applied to the bridge arm containing the plug filled with mineral particles (C) to balance the current through a calibrated resistance (D) furnished by the potentiometer (A). To extend the range of the measurements, the calibrated resistance (D) is either a 10^6, 10^5, or a 5×10^4-ohm wire-wound resistance manufactured by International Resistance Corp. When zero deflection of the electrometer (E) across the 10^{12}-ohm resistance (F) is obtained, the ratio of the required potentials, B:A, is equal to the resistance (C) in megohms if D has the value of one megohm. The dc bridge circuit can be superimposed onto the streaming potential circuit by means of suitable switches. The cell constant is determined in the usual manner with 0.1 N KCl. To measure the specific conductance of solutions with this bridge, flow of solution must be stopped.

Zeta potentials at 25°C can be calculated from the streaming potential in millivolts, E, the driving pressure in centimeters of mercury, P, and the specific conductance of the solution within the plug, λ, by the following equation:

$$\zeta = 9.69\,\frac{E\,\lambda}{P}\ \text{mv.} \qquad [1]$$

The accuracy of data obtained with these pieces of apparatus is within 0.5 pct. With this method it is possible to measure streaming potentials in solutions up to about 0.1 molar. Special care must be used in interpreting experimental data because of the effect of surface conductance in dilute solutions.[1-4]

Acknowledgment

The author wishes to acknowledge the U. S. Atomic Energy Commission for financial support in setting up and using this technique for studying mineral surfaces. He also acknowledges the suggestions of A. M. Gaudin and H. J. Modi.

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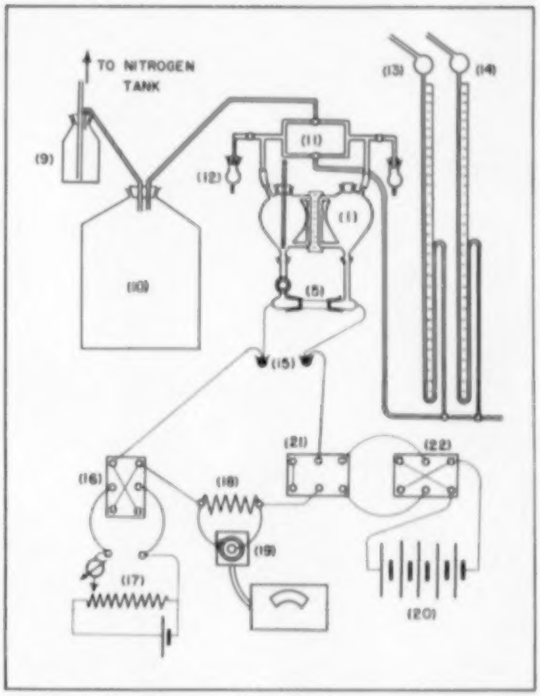

Fig. 2—Assembled streaming potential apparatus. See text for identification of numbered parts.

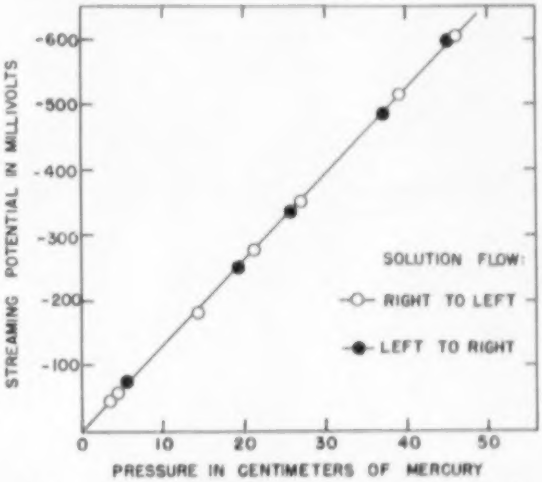

Fig. 3—Streaming potential of quartz plug as a function of driving pressure.

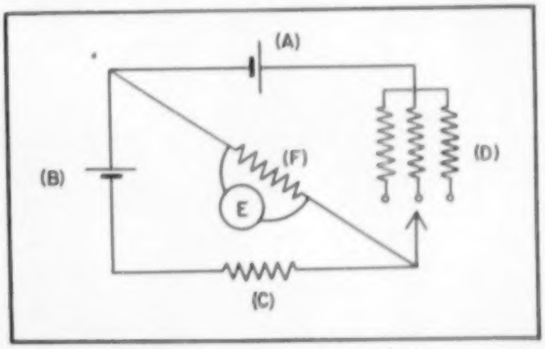

Fig. 4—Direct current conductance bridge.

Discussion

Comminution as a Chemical Reaction

by K. F. G. Hosking

(*MINING ENGINEERING*, page 561, June 1955; AIME *Trans.*, vol. 202)

I read Professor Gaudin's paper with great interest and pleasure because for some time I have held that the chemical aspect of comminution is a subject of considerable importance to the mineral dresser and deserves to be thoroughly investigated. It does seem appropriate, however, to emphasize the fact that "fresh" edges and corners produced by the grinding of solids display enhanced reactivity has been recognized and utilized in the development of certain mineral identification techniques. Some of these techniques are worth noting, not only because they might facilitate research in the aspect of mineral dressing under discussion, but also because they emphasize the fact that many mineral species commonly regarded as being very inert can display a surprising reactivity when in the freshly ground state.

In 1951 Isakov[6] published a number of tests for the components of certain mineral species which depend essentially on grinding in a mortar a mixture of the material under investigation with a solid reagent. Thus when stibnite, $4(Sb_2S_3)$, is ground with sodium or potassium hydroxide, the antimony is revealed by a momentary development of a yellow color which changes in air to orange-red. Other antimony minerals need a preliminary treatment before the test can be carried out. This consists of grinding with aluminium sulfate, ferric sulfate or potassium bisulfate, and breathing upon the resultant mixture.

I have employed a similar technique to determine the approximate magnesia content of certain limestones.[7] The method depends essentially on the fact that when a sample of limestone is ground under controlled conditions with solutions of sodium hydroxide and Titan yellow the color of the final product is, within limits, a function of the amount of magnesia present.

I have also shown that the components of a wide range of minerals can be identified by applying chemicals to their streaks on portions of vitrified, unglazed floor tiles, etc. Under such circumstances the diversity of the reactions which take place in the cold (because of the reactivity of fresh corners and edges) is surprising. Thus, for example, if a garnierite, $(Ni,Mg)_3Si_2O_5(OH)_4$, streak is treated first with a drop of 0.880 ammonia and then with a drop of a 1 pct alcoholic dimethylglyoxime it immediately becomes red, indicating the presence of nickel.[8]

Stevens and Carron[9] have evolved a simple field test for distinguishing minerals by "abrasion pH." A soft nonabsorbent mineral is scratched in a drop of water on a streak plate until a milky suspension is formed. A piece of pH indicator paper is dipped into the suspension, after which it is removed and the maximum deviation from neutrality noted. When a hard mineral or one which absorbs water is being tested, fragments are first ground for 1 min with a few drops of water in a mortar to make a heavy suspension. The importance of the findings of such tests to mineral dressing may be judged by the abrasion pH values, Table II, recorded by Stevens and Carron for certain species usually regarded as comparatively inert.

The combined results of the above researches clearly indicate that comminution is capable of altering the pH of a pulp and of causing the chemical nature of the surfaces of some of the components to be profoundly changed. Depending on circumstances such surface alterations may have a beneficial or an adverse effect if these products are subsequently subjected to flotation. The tests also suggest that by grinding "inert" minerals with appropriate solid or liquid reagents "reactive" surfaces may be developed which might facilitate separations by flotation.

Table II. Stevens and Carron Values

Mineral	Recorded Abrasion pH
Kaolinite	5, 6, and 7
Cassiterite	6
Columbite	6
Zircon	6
Biotite	8 and 9
Albite	9 and 10

It is an interesting and instructive problem to determine the reactions that are likely to take place when dry solid substances are subjected to comminution and to the unavoidable heat liberated during the process. To do this it is theoretically necessary to know the free energy values of the reactants and possible resultants, but unfortunately there is a dearth of such data! However, the heats of formation of many substances are known, and generally speaking, if in a reaction of the type $AB + CD = AD + CB$ the sum of the heats of formation of AB and CD is less than that of AD and CB the reaction will probably proceed to the right. Thus, according to a note I have (the author of which I cannot name) if PbS (black) is warmed with $CdSO_4$ (white), $PbSO_4$ (white) and CdS (yellow) are formed, and that the reaction does, in fact, take place is indicated by the change in color of the mixture. The reaction is expected, as the sum of the heats of formation of PbS and $CdSO_4$ is less than that of $PbSO_4$ and CdS (as shown below).

$$\begin{aligned} PbS + CdSO_4 &= PbSO_4 + CdS \\ 22.2 + 218.0 &< 216.2 + 33.9 \end{aligned}$$

Finally, certain other aspects of the chemistry of comminution, which are neither mentioned by Professor Gaudin nor referred to by me are to be found in a paper by Welsh[10] and in the printed discussion thereof.

A. M. Gaudin *(author's reply)*—The observations contributed by Dr. Hosking are indeed welcome, as they add to our experimental knowledge of a topic which is believed to be of the first importance. In connection with the experiments cited it should be kept in mind that oxidation, hydration, and carbonation at various rates should always be deemed to be possibilities when grinding is done in water or in air, even in "industrially dry" air. Special precautions might lead to sufficient minimizing of these reactions and to the assertion, instead, of deliberately-created reactions.

The author wishes to thank Dr. Hosking for his contribution.

References

[6] P. M. Isakov: Method of Grinding in Analytical Chemistry. *Journal of Analytical Chemistry*, U.S.S.R., 1951, vol. 6, pp. 281-287.

[7] K. F. Hosking: Magnesia in Limestone. *Mining Magazine*, 1956, vol. 94, pp. 16-17.

[8] K. F. G. Hosking: *Identification of Economic Minerals by Rapid Chemical Methods*. Unpublished doctoral thesis, University of London, 1954.

[9] R. E. Stevens and M. K. Carron: Simple Field for Distinguishing Minerals by Abrasion pH. *American Mineralogist*, 1948, vol. 33, pp. 31-49.

[10] A. J. E. Welsh: The Relation of Crystal Lattice Discontinuities to Mineral Dressing. *Trans.*, Institute of Mining and Metallurgy, London, 1953, pp. 387-392.

AIME Annual Meeting

New Orleans

February 24 to 28, 1957

TIME TO MAKE PLANS . . .

. . . for the 1957 Annual Meeting—top flight technical program—varied social events—and all the New Orleans attractions! Mining and Petroleum Branch headquarters will be the Roosevelt Hotel, and the Metals Branch headquarters will be the Jung Hotel. The meeting is under the general sponsorship of the Delta Section.

TECHNICAL PROGRAM

Schedules are already well advanced to bring you one of the best balanced programs ever. The All-Institute meeting on Tuesday afternoon will be one of the highlights.

SOCIAL EVENTS

All traditional Annual Meeting gatherings are on the schedule—Welcoming Luncheon, Dinner-Smoker, Informal Dance, Annual Banquet—as well as the Branch and Divisional activities. The informal dance will be held aboard the *S.S. President*.

LADIES' PROGRAM

Details so far set include a Luncheon and Fashion Show on Tuesday and coffee hour Monday morning.

Turn the page for more on "What to See and Do" in New Orleans.................................

MAIL THIS CARD

to request hotel reservations. Rooms have been reserved in the following hotels:

Roosevelt
Jung
Monteleone
St. Charles
New Orleans
De Soto
Pontchartrain
La Salle

I expect to attend the AIME Annual Meeting to be held in New Orleans, La., February 24 to 28, 1957 and request reservation of a ____________________ bedroom. My choice of hotel is:
(Double or Twin)

First Choice____________________

Second Choice____________________

Third Choice____________________

I expect to arrive about ____________ on ____________
(A.M. or P.M.) (Date)

I expect to leave about ____________ on ____________
(A.M. or P.M.) (Date)

I will share a room with____________________

Remarks ____________________

NAME ____________________

FIRM ____________________

ADDRESS ____________________

____

What to Do and See in New Orleans . . . .

No other city in this country is like **New Orleans.** It offers more varied types of interest than any other city in the United States and is perhaps the only city that gives the visitor the feeling that he is both in the United States and out of it. New Orleans offers the contrast of an old and a new civilization.

To some tourists, New Orleans is first of all a place to eat, drink and be merry, it's Bourbon St., the night life beat, the "little Paris of gaiety, girls, gags, gourmets and jazz."

Yet New Orleans is likewise a pious, virtuous city, with a strong continental flavor, offering a rich variety of experiences for more serious-minded folk.

And certainly, with its Vieux Carre, or "Old Square," once the walled city of Nouvelle Orleans, it is one of the most interesting spots in the United States.

New Orleans has been called the gourmet's capitol of the world. Some of its restaurants enjoy international fame, and then there are dozens not as well known, but as notable for their distinctive cuisine. French, Creole, Italian, Mexican and Chinese foods, on a par with the best in other cities, reward the adventurer; whoever will make an effort to find these smaller but interesting eating places will discover the most fascinating and varied and delicious food in America.

Dixieland jazz is the real New Orleans music, born here and perfected here, and still heard here . . . some of the best of the oldtimers play in various spots about the city.

New Orleans is truly an American city but more than any other American city it offers a distinct foreign atmosphere. The city was founded by the French in 1718 and later came under the domination of the Spanish. So when in 1803 New Orleans became an American city, it possessed a well established civilization, steeped in Latin tradition. Much of that tradition has been preserved to this day. Many of the the scenes and settings of the romances and tragedies of old likewise have been preserved and the visitor to New Orleans today can still perceive the atmosphere of old France and old Spain and can still feel the influence of this early Creole period.

If one likes history and romance, New Orleans has it. The visitor will find it in the **Vieux Carre,** which today is more popularly known as the French Quarter, where the old-world atmosphere of the early city can be captured. This old section of New Orleans is particularly fascinating because of its narrow streets, its sloping roofs, shaded patios, fancy iron balconies, fan windows and mysterious alleys and passageways. Still re-echoing from this old section are the sins or noble deeds of such notable personalities as the **Lafitte** pirates, **Audubon** the naturalist, **Morphy** the chess wizard, **Patti** and **Lind** the singers, **Andrew Jackson, Paul Tulane, John McDonogh,** the **Baroness Pontalba** and a host of others.

Grouped around **Jackson Square** are the most interesting buildings of the **Vieux Carre.** This square is the old **Place d'Armes** of French New Orleans and when designed was meant to be the very soul of the city. There the early settlers built the old parish church, which was destroyed by fire but which still lives today in the **St. Louis Cathedral.** The Cathedral, which dates back to 1794, has venerable neighbors in the **Cabildo** and the **Presbytere.** In historical importance, the Cabildo eclipses its twin in appearance, the Presbytere, because it was in the hallowed halls of the former that the ceremonies connected with the transfer of the **Louisiana Territory** took place, giving the United States new territory from which thirteen of the states have been carved in whole or part. The Cabildo and the Presbytere now house the priceless relics maintained by the **Louisiana State Museum.**

The French and Spanish inhabitants of New Orleans were proud of their Latin heritage and resentful of any attempt to impose a new system upon them or their city. Thus, when Louisiana became part of the United States in 1803 and there came a great influx of Americans with different customs and a different language, it was but natural that conflicts and antipathies should arise. This resulted in the Americans establishing a colony of their own and what was virtually a different city developed on the opposite side of Canal St., still the dividing line of the old city and the new, still the dividing line of uptown and downtown.

TOURS: Among the typical organized tours of the city available for the ardent sightseer are: Harbor Sights, 2½ hr.; City and Suburbs, 75 miles, 5½ hr.; Circle tour of Garden District, Lake and River; Modern New Orleans; Historic Chalmette River and Vieux Carre; as well as all inclusive tours of old and new city areas.

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aime news

Rocky Mountain Minerals Conference

September 26-28, 1956

Once again Salt Lake City will play host to the Rocky Mountain Minerals Conference for their third annual meeting Wednesday to Friday, Sept. 26-28, 1956. The program is designed to attract members of all three branches. The AIME Utah Section, sponsoring the Conference for the second year, has arranged a variety of technical sessions, symposiums and field trips, as well as more relaxing activities such as luncheons, cocktail parties and a dinner-dance. A new feature will be the Miner's Breakfast, and those attending are urged to insure informality by coming unshaven and in western garb. A special luncheon and fashion show for the ladies will be held at the Salt Lake Country Club, and a coffee party at the Newhouse Hotel.

Technical sessions will cover such topics as coal and iron mining, monazite deposits, production of titanium metals, the manufacture of sulfuric acid and processing uranium ores. These morning and afternoon sessions on Wednesday and Thursday will not conflict since there are no simultaneous programs scheduled.

At the Welcoming Luncheon Wednesday, the guest speaker is Governor J. Bracken Lee of Utah. A gay evening is assured when the mining companies and suppliers hold their cocktail party that night. Thursday's highlight is the Minerals Luncheon, at which time John C. Kinnear, Jr., EMD Chairman, will address the group. The Friday symposium on loading and transportation promises to be a rewarding one, with specialists in the field offering a comprehensive picture of new methods, practices and equipment. Friday afternoon has been reserved for field trips. Buses will be provided to Calera Cobalt Refinery, Utah Oil Refinery, Western Phosphates Mill and Vitro Uranium Mill.

Officers of the Utah Section, conference host, are Neil Plummer, chairman, and Dan McElhattan, vice chairman. R. C. Cole, general chairman, and A. J. Thuli, assistant general chairman, are responsible for conference arrangements. Mrs. F. V. Richards will supervise arrangements for the ladies' activities.

Envelopes containing program, pre-registration form, application for housing, and return envelopes will be mailed in August to about 8000 members in 11 Western States, Minnesota and South Dakota. Mail requests for hotel reservations to: Utah Section, AIME, 815 Kearns Bldg., Salt Lake City.

See page 838 for list of technical sessions, and social events.

Northeastern Mining Branch Conference

November 8-10, 1956

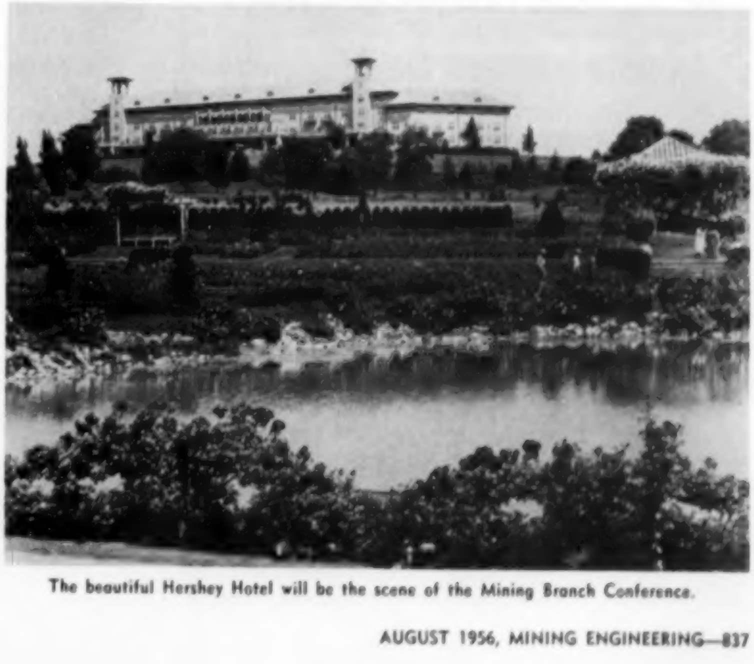
The preliminary program has been announced for the Northeastern Mining Branch Conference to be held on Nov. 8, 9, and 10, at the Hotel Hershey, Hershey, Pa.

The speaker at the Welcoming Luncheon on Thursday will be A. F. Peterson, vice president, Mining Div., Bethlehem Steel Co. On Friday, Grover J. Holt, AIME President-elect, and general manager, Ore Mining Dept., Cleveland-Cliffs Iron Co., will speak at the Mining Branch Luncheon.

Technical sessions have been scheduled to cover mining, geology, geophysics, industrial minerals, and concentration. Several field trips have been planned, including a visit to the charcoal furnace built in 1743.

On Saturday afternoon there will be a golf tournament, for which prizes will be given by the Colorado Fuel & Iron Co.

The program for the ladies will include a tour through the plant of Hershey Chocolate Corp., and a visit to the Pennsylvania Dutch Museum.



The beautiful Hershey Hotel will be the scene of the Mining Branch Conference.

Rocky Mountain Minerals Conference Program

Data as of July 1956

WEDNESDAY, SEPTEMBER 26

Technical Session 9:00 am

1. **Pressure Leaching and Reduction at Calera's Garfield Refinery**
   by J. Stanley Mitchell, plant superintendent, Calera Mining Co.
2. **Coal Mining by Mechanical Methods**
   by John Paparakis, manager, Sunnyside Div., Kaiser Steel Corp.
3. **Oil and Gas Possibilities of the Great Basin Area**
   by Dorsey Hager, consulting geologist.
4. **Management Measures An Engineer**
   by Charles Hilton, B. J. DiSanto, J. F. Dugan, I. K. Hearn, R. S. Stone, and Clark L. Wilson.

Ladies' Coffee Party at Newhouse Hotel 9:00 am

Welcoming Luncheon 12:30 pm

Speaker: Hon. J. Bracken Lee, Governor of Utah

Technical Session 2:30 pm

1. **Iron Mining in Southwest Utah**
   by Robert F. Loer, superintendent, Desert Mound Mine, Columbia Iron Mining Co.
2. **Transmission of Natural Gas in the Rocky Mountain Area**
   by Fulton Copp, assistant to the vice president, Pacific Northwest Pipeline Corp.
3. **The Production of Elemental Phosphorus**
   by V. N. Antaki, staff engineer, Westvaco Mineral Products Div., Food Machinery & Chemical Corp.
4. **The Valley County, Idaho, Monazite Deposits**
   by George A. McHugh, manager of mines, J. R. Simplot Co.

Mining Companies and Suppliers Cocktail Party 6:30 pm

THURSDAY, SEPTEMBER 27

Technical Session 9 am

1. **Geology of the Uranium Deposits of the Ambrosia Lake District, McKinley County, New Mexico**
   by R. G. Young, geologist, A.E.C.
2. **Mining and Geology at the Idaho Almend Mercury Mine, Near Weiser, Idaho**
   by J. R. Reynolds, chief engineer, Rare Metals Corp. of America.
3. **Production of Titanium Metal at Henderson, Nev.**
   by R. R. Lloyd, process superintendent, Titanium Metals Corp. of America.
4. **The Manufacture of Sulfuric Acid From Metallurgical Gases at the Garfield Smelter**
   by A. S. Neslen, Garfield Chem. & Mfg. Co.

Minerals Luncheon 12:30 pm

Speaker: John C. Kinnear, Jr., chairman, EMD

Ladies' Luncheon-Fashion Show, Salt Lake Country Club, 12:30 pm

Technical Session 2:30 pm

1. **Award Paper**—University of Utah Student. Winner to be announced later.
2. **Innovations in Processing Uranium Ores**
   by W. L. Lennemann, metallurgical adviser, Processing Div., A.E.C.; J. B. Rosenbaum, metallurgist, and J. Bruce Clemmer, chief, Metallurgical Div., Region IV, USBM.
3. **Sand Filling at the Galena Mine**
   by Norman Visnes, Supt., Galena Unit, American Smelting & Refining Co.
4. **New Methods-Mining Gilsonite Without Blasting**
   by J. H. Baker, assistant production manager, American Gilsonite Co.

FRIDAY, SEPTEMBER 28

Miner's Breakfast 7:30 am

Technical Session 9 am

Symposium—Loading and Transportation

Moderator—J. M. Ehrhorn, director, Industrial Development, U.S. Smelting & Refining Co.
R. I. Williams, maintenance foreman, Ray Mines Div., Kennecott Copper Corp.
W. H. Wamsley, Supt., Pacific Coast Borax Co.
Tom Berry, Supt., Dravo Construction Co.
A. R. Sims, general superintendent of mines, Anaconda Co.
Robert F. Love, Supt., Intermountain Chem. Corp.
Lawrence W. Casteel, Supt., Indian Creek Mine, St. Joseph Lead Co.
Dale I. Hayes, assistant to the president, American Lead Zinc & Smelting Co.

Friday Afternoon—Field Trips

INDUSTRIAL MINERALS DIVISION

NEWSLETTER

Dear Members of the
Industrial Minerals Division:

The Executive Committee of the Division met in N. Y. in May. Among the main topics discussed were: the Annual Meeting program; the new IndMD Directory; the new edition of *Industrial Minerals and Rocks*; the 1956 Northeastern Mining Branch Regional Conference at Hershey, Penn.; a new name for one of our commodity committees; and suggested revision of IndMD bylaws.

W. B. Stephenson, chairman of the committee planning the Regional Meeting in Hershey, November 8th to 9th, 1956, attended our meeting and reported on the progress of their plans. Industrial Minerals Division was invited to sponsor a session at the meeting, and several papers from the cement industry have already been scheduled on the program. Plans include an IndMD field trip and a golf tournament.

Dave Larrabee's Committee on Rare Minerals now has a new name—*Rare and Radioactive Minerals*. This change has been brought about by the discoveries of the past several years. It seems uranium is no longer a rare mineral. In fact, it may be even more common than we now suppose. With Blind River, Ambrosia Lake, the Laguna-Jackpile deposits etc., there is little reason for the description "rare uranium minerals" on carnotite or autunite.

The new edition of *Industrial Minerals and Rocks* was also discussed, and the Executive Committee was pleased to learn that funds have been approved for this project by the Mudd Fund Committee. J. L. Gillson accepted the responsibility of heading the committee which will select an editor and supervise the work of revision.

A project on a separate Divisional Directory has been initiated, and the new committee is headed by T. E. Gillingham. It is contemplated that this directory will not only list the names of all AIME members whose primary interest is industrial minerals, but will also classify our members according to geographic location and commodity interest groups as well. This may require several months and considerable canvassing.

Tom Gillingham, program chairman of our Division, has been busy contacting the officers of some 35 AIME local sections whose major interest is in the Mining Branch. He has requested their contributions and suggestions on the annual meeting program. This idea of asking local sections to recommend or submit *proven* papers to the annual meeting program seems to be working fairly well, and offers have come in which may even be of assistance to other divisions. Papers well received at local or regional meetings and judged to be worthy contributions to the profession seem to be the most logical choice for presentation at annual meetings.

Pauline Moyd reports her Ceramic Raw Materials Committee is working hard on plans for an interesting session in New Orleans. Dave Larrabee is looking for papers on nuclear energy for the Nuclear Engineering and Science Congress in Philadelphia, March 10-16, 1957. Those who have ideas or suggestions for papers, can write to: D. M. Larrabee, U. S. Geological Survey, 4203 GSA Building, Washington, 25, D. C.

There will be six or seven IndMD sessions at the Annual Meeting including a joint session with MBD.

John Ames, R. C. Stephenson, Harold Bannerman, and R. J. Lund have been working on a revision of the IndMD bylaws, to be considered by the IndMD Executive Committee in the fall and then presented to the AIME Board of Directors.

R. H. Feirabend, chairman, Field Trip Committee, 1957 Annual Meeting, reports several trips which may be of interest to our members: to the Grande Ecaille Operations, Freeport Sulphur Co.; and to the operations of the International Salt Co.

If this newsletter is to be continued successfully, we need more items from our membership. Kindly send written communications only, to Robert M. Grogan, Secretary IndMD, AIME, Development Dept., E. I. du Pont de Nemours & Co., du Pont Building, Wilmington, Del.

Our next IndMD Newsletter will appear in the November issue.—*R.M.G.*

Consultants Please Note:

The office of the Mining Branch Secretary would like to revise and bring up to date their files on members who serve as **full time or part time consultants** to the Mining Industry. This information is needed to properly answer the many requests which are directed to our attention by persons writing in from all parts of the world. If you are interested in having your name listed and kept in this up-to-date file, kindly send your name, latest permanent address, and special field of endeavor or service as a consultant on a "Two Penny" Post Card to: **Arnold Buzzalini, Mining Branch, AIME, 29 West 39th Street, New York 18, New York.**

Committee Recommends New York For Engineering Center Site

On June 22, directors of the governing boards of AIME, ASME, AIEE, AIChE, and ASCE, were mailed the report of the Special Task Committee of 15, appointed to make recommendations with regard to the site of the Engineering Societies Center. The recommendations are as follows:

Key Points

► **Item 1**—The Engineering Societies Center be located in N. Y. C.

► **Item 2**—The 39th-40th St. site be continued in use as the site of the Engineering Societies Center.

If rebuilding in that area proves impracticable, a comparable site should then be sought in midtown N. Y.

We suggest that the Governing Boards also adopt these further recommendations for inaugurating action:

► **Item 3**—The United Engineering Trustees, Inc., be authorized to take proper legal action for expansion by the addition of the American Institute of Chemical Engineers to the incorporators when properly qualified.

► **Item 4**—The United Engineering Trustees, Inc., be authorized to raise money and accept contributions; accept the offer of the Kelly Committee; place contributions in UET Capital Fund Assets; employ architects, engineers, and attorneys; let contracts for reconstruction of the present Engineering Societies building and/or a new building or buildings; pay all costs out of the Capital Fund Assets; and operate and maintain the new Engineering Societies Center.

► **Item 5**—The plans for the new and enlarged Engineering Societies Center be made with ample optimism with respect to the future growth of the five societies immediately involved. These facilities should be such as to attract and hold all of the Engineering Profession, thus fostering unity and cooperation along broad lines.

The vote of the Special Task Committee, the members of each of the five Societies voting as a unit as prescribed, is unanimously in favor of these recommendations."

The Special Task Committee was composed of the following: E. G. Bailey, T. H. Chilton, Harold Decker, B. F. Dodge, E. S. Fields, J. E. Housley, R. P. Kite, M. G. Lockwood, F. A. Marston, J. W. Parker, L. M. Robertson, H. DeWitt Smith, J. M. Todd, R. B. Wiley, and C. E. Williams.

United Engineering Trustees, Inc., is a corporation formed by the four engineering societies first named to be the titular owner of the present Engineering Societies Building at 29-33 W. 39th St., in N. Y.

Anticipating the report, the AIME Board, at a meeting on June 21, voted that all Directors be given an opportunity to vote by letter ballot on the recommendations of the committee. The ASCE, by a majority vote, was the first to accept the recommendations. AIME Directors, also by a majority vote, did likewise in July. The ASME vote was to be registered by the end of July, the AIEE on August 17, and the AIChE on Sept. 9. If all five societies accept, it will still remain to be decided whether the present building will be remodeled or another midtown site secured. Although United Engineering Trustees is authorized to "raise money and accept contributions," presumably the offer of the Kelly Committee, to raise the necessary funds for a new Engineering Center, will be accepted. (See Mining Engineering, August 1955 p. 800; Journal of Metals, August 1955, p. 924; Journal of Petroleum Technology, August 1955, p. 38.)

MGG Lists Tentative Annual Meeting Program

The Mining Subdivision of MGG has tentatively scheduled several sessions for the 1957 Annual Meeting. Among the five under consideration at the present are: a symposium on shaft sinking; a session on mining development in the Southeast; and an all-Canadian session.

R. H. Feirabend, chairman of the field trip committee reports that among the trips which may be of special interest to the mining fraternity are a visit to the Grande Ecaille Operations of the Freeport Sulfur Co., and a trip to the International Salt Co.

R. P. Full, coordinator of MGG's three subdivision programs, is presently working on plans for a joint MGG business session to be followed by a panel on *The Atomic Energy Story*—from the time of the Manhattan project to the present.

Around the Sections

Some of the members and guests at dinner during the summer meeting of the Pennsylvania Anthracite Section. Carl E. Reistle, Jr., was the principal speaker, and W. Julian Parton was the presiding officer.

• The **Pennsylvania Anthracite Section** held its annual summer meeting on June 28 at Split Rock Lodge. AIME President Carl E. Reistle, who flew in from Houston with Mrs. Reistle, Ernest Kirkendall, AIME Secretary, and David Mitchell, Secretary, Coal Div., AIME, were among the many prominent members attending. During the meeting the following officers were elected: Floyd S. Sanders, Chairman; Walter B. Petzold, Vice Chairman; and Thomas R. Weichel, Secretary-Treasurer. Executive Committee: W. W. Kay, Robert W. Walsh, Thomas C. Price, Donald Markle, Sr., Wesley Stonebraker, James H. Pierce, and Francis O. Case. Among those responsible for the success of the meeting were: John S. Marshall, chairman of the Arrangements Committee, and Floyd S. Sanders, in charge of the Program Committee.

• The May meeting of the **Black Hills Section** was held at the Lead Country Club, Lead. Langan Swent, assistant to the general manager, Homestake Mining Co., gave an interesting talk on the properties of the San Luis Mining Co., in and around Tayoltita, Durango, Mexico. Student associates attending the meeting were guests of the Section.

• The **Washington, D. C., Section** made its annual field trip on June 5. This year arrangements were made by J. C. Williamson for members to tour the Halethorpe plant of Kaiser Aluminum & Chemical Corp. in Baltimore. After the tour a buffet luncheon was served by the company at Friendship International Airport.

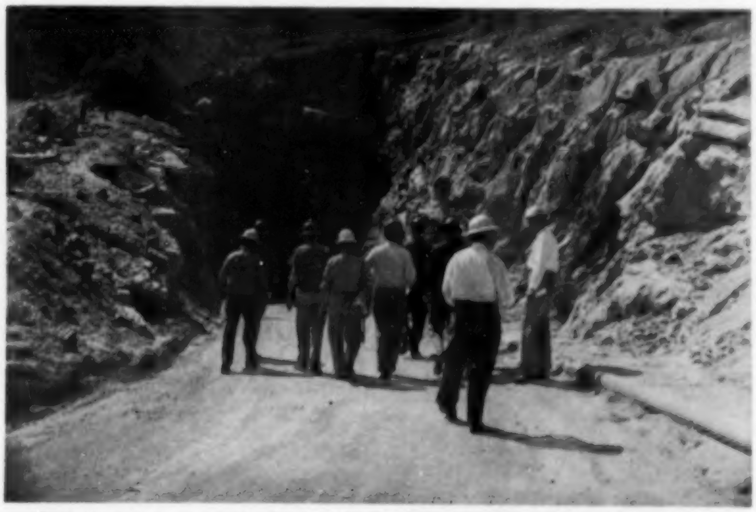
• The **Montana Section** held a joint meeting on May 26 with the Montana Society of Engineers at Anaconda. F. W. Beichley, regional engineer and service supervisor, Westinghouse Corp., gave a talk entitled "Research —Industries Greatest Adventure." The technical session was preceded by an inspection tour of the Anaconda Reduction Works arranged by R. G. Bowman.

• The **Colorado MBD Subsection** held its annual meeting jointly with the Pikes Peak Subsection on May 19 at the Broadmoor Hotel, Colorado Springs. AIME President, Carl E. Reistle, Jr., addressed the business meeting and the dinner group. Mr. Reistle discussed the aims of the Institute and stressed the need for an active membership. During the business session Frank Windolph reviewed the events of the past year. The following officers were elected: W. T. Ahlborg, Chairman; J. R. Purdy, Vice-Chairman; J. L. Lake, Secretary-Treasurer. Five papers were presented at the technical sessions under the chairmanship of John Ferguson. The ladies' program included a trip to Cheyenne Mountain zoo and Will Rogers' shrine.

• AIME President, Carl E. Reistle, Jr., was the guest of honor at a dinner-meeting held jointly by the **Colorado Section** and the **Denver Petroleum Section** on May 21 at the University Club, Denver. During the meeting Mr. Reistle was presented with the Denver Dollar Award by Clayton Hill, manager of revenue, City of Denver, in behalf of the mayor and people of Denver. This very singular award was given to Mr. Reistle in recognition of his stature in the minerals industry and as a symbol of the appreciation and hospitality which the City of Denver extends to the oil industry.

• The **Reno, Nev., Subsection** met on June 8 at El Cortez Hotel. Karel Havelik, formerly of Prague, Czechoslovakia, and now of Reno, spoke on his personal experiences in the slave labor uranium mines of Czechoslovakia. The Section met on June 5 at the Supper Club, Moana Lane, to hear R. J. Rhinehart, president-elect of the National Society of Professional Engineers.

• The **Central Appalachian Section** held its annual spring meeting on May 18 and 19 at the Martha Washington Inn, Abingdon, Va. Several interesting papers were presented at the technical sessions. The Section Chairman, Rhesa M. Allen, presided at the banquet. Fred K. Prosser, Norfolk & Western Railroad, was toastmaster, and introduced the guest speaker, Robert Porterfield, director of the Virginia State (Barter) theater. Mr. Porterfield gave a humorous talk on *Virginia Hams*. The ladies' program included a tour of the Cumbow China Factory, and a visit to the Barter Theater. The meeting ended with a field trip through the Foote Mineral Co. mine at Sunbright, Va.



One of the tour groups entering the Foote Mineral Co. high calcium limestone mine at Sunbright, Va., during the annual spring meeting of the Central Appalachian Section in May. Trucks load directly in the mine which has 35 ft high by 75 ft wide rooms.

Mexico Section Joins International Geological Congress in September

The AIME Mexico Section will hold their September monthly meeting in Mexico City. This meeting is planned to coincide with the 20th International Geological Congress scheduled in that city.

The Dinner Session on September 10, will be addressed by AIME President Carl E. Reistle, and Thomas S. Lovering, chief of the geochemical exploration branch, U. S. Geological Survey. A gay evening is planned. In addition to the speakers, gala entertainment is on the agenda.

All AIME members interested in attending the dinner, to be held at the University Club, are urged to contact J. T. Carty, Secretary-Treasurer, Mexico Section, AIME, Dolores 17-901, Mexico 1, D.F. Space is limited and registration will close Sept. 5, 1956 at 3 pm. Tickets are $6.00 each.

Around the Sections

• The **Oregon Section** met on June 15 at Burns Restaurant, Portland. William W. Wiltschko presided, with 37 attending. The principal speaker was Donald H. Tilson, assistant manager, northwest operations, Aluminum Co. of America, Vancouver, Wash. Mr. Tilson's subject was *Comparative Processing of Aluminum Oxide and Aluminum in the United States and Yugoslavia.* The program chairmen for the Pacific Northwest Regional Conference to be held in Portland April 11, 12, and 13, 1957, were announced. They are as follows: Hollis Dole and Fay Libbey, Geology; Ralph Mason, Industrial Minerals; Earl Hayes, Metals; P. R. Hines, Beneficiation. A tour of Electric Steel Foundry Co., Portland, is planned for the Section's September meeting.

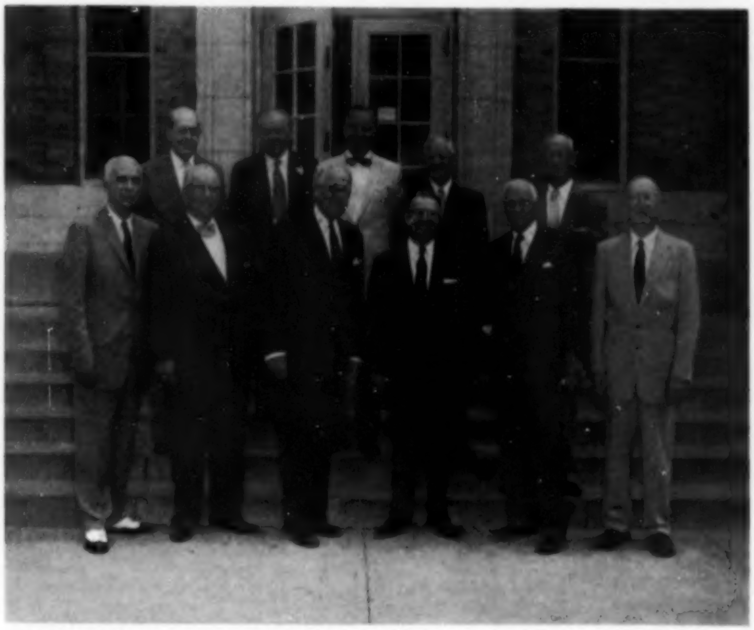
• Two busloads of members and guests of the **Adirondack Section** toured the St. Lawrence Power Project and Seaway on May 26. Members were surprised at the progress made since last year and are looking forward to another visit next year. Arrangements for the tour were made by A. L. Hall of Cabot Carbon Co. In the evening the group met at the Village Inn near Massena for cocktails and dinner. The speaker, William Thompson, geologist for Uhl, Hall & Rich, described the many geological problems involved in the Project.

• The **Colorado Plateau Section** held its summer meeting on June 16 at the Grand Imperial Hotel, Silverton. At the technical session Jack Seerley, manager, Rico Argentine Co., described the Rico Argentine operation, and Harold Kirkemo of Grand Junction, outlined the geology of the Golden King mine. A discussion on uranium followed, with Page Edwards, Vanadium Corp. of America, as moderator. In the evening members and guests attended a dinner and dance.

• The ladies were not forgotten at the second annual joint meeting of the **Casper, Denver,** and **Billings** chapters of AIME in Casper, Wyo., May 19-20. A special fashion luncheon, held in the Gladstone Hotel featured the latest modes modeled by the distaff of Casper. Other social events included a cocktail hour on Friday and the convention dinner that evening.

At the technical sessions on Saturday morning and afternoon, the following papers were presented: *An Atom Smasher for Well Logging*, by Philip W. Martin; and *Water Flood Operations at North Meadow Creek Sussex Sand Unit*, by L. B. Myers.

Vice President Boza Of Peru Receives Honorary Degree



Vice President Boza of Peru with Curtis L. Wilson, dean, Missouri School of Mines and Metallurgy, and other prominent graduates, at the commencement exercises in May.

The honorary degree of Doctor of Engineering was conferred upon Vice President Hector Boza of Peru by the University of Missouri School of Mines and Metallurgy, Rolla, Mo., during the School's commencement exercises last May.

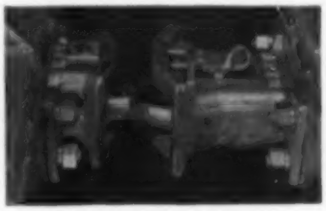
Vice President Boza, who is also President of the Senate in Peru, graduated from the university in 1911 and was awarded the professional degree of Mining Engineer in 1916.

Philadelphia Site Of EJC Nuclear Congress Scheduled March 1957

The Second EJC Nuclear Engineering and Science Congress and accompanying Atomic Exposition will be held March 11-15, 1957 in Philadelphia. Coordinated by Engineers Joint Council, the technical sessions, over-all Congress meetings, and the Exposition, will be held in Convention Hall.

Nineteen major engineering and scientific societies will participate. The Congress expects to top their 1955 attendance record when nearly 3000 engineers and scientists from industry, business, education and government attended. The Atomic Exposition, which will display the latest developments in the application of nuclear energy, is expected to draw a greater audience than the 13,000 who saw the Cleveland exhibits in 1955. There will be more exhibitors too.

Walter G. Whitman, who was chairman of the United States delegation to the 1955 Geneva Conference on Atomic Energy and is head of chemical engineering at MIT, has been named chairman of the general committee for the Congress. Chairman of the program committee is Bruce R. Prentice, General Electric Co. The Atomic Exposition sponsored by the AICE will be under the management of Denham & Co., of Detroit.



AIME-ASME Joint Solid Fuels Conference

The Sheraton-Park Hotel in Washington, D. C. will be the site of the AIME-ASME Joint Solid Fuels Conference October 25-26, 1956.

W. Bradbury, program chairman, has announced the tentative schedule. The Oct. 25 morning session will hear F. Guy discuss *Recent Stoker Development in an Expanding Spreader-Stoker Field.* This will be followed by a talk on the *Effect of Atomic Energy on the Future of Fossil Fuels* by H. Perry and R. C. Dalzell. The session will close with a report on *Determination of Heat Content of Coal by Regression Analysis,* by R. L. Paseck and R. M. Lundberg. The afternoon session will hear talks on *Government Development and Research Activity in Solid Fuel,* by T. R. Scollon and H. Perry; *Underground Gasification in Great Britain,* by C. A. Masterman; and *Coal Industry Research* by J. R. Garvey.

Presiding at the Welcoming Luncheon is L. C. McCabe, president of Resources Inc., who will present the guest speaker, J. W. Barker, president of ASME.

Following the cocktail party at 6 pm, the Annual Banquet will feature the presentation of the Percy Nicholls Award and a guest speaker, to be announced later. Entertainment will be provided by the U. S. Navy Sea Chanters Choral Group.

Highlight of the morning session, Oct. 26, is the Symposium on Combustion with N. D. Phillips, A. Bogot and F. J. Ceely as speakers. E. C. McMann will also report on *Fly Ash Refiring.* In the afternoon F. G. Seeley, Jr. will discuss *Coal as a Source of Power for the Aluminum Industry.* Also scheduled are talks by W. A. McFarlane on *Industrial Fuel Utilization in the United Kingdom,* and G. A. Lamb on *Changing Market Patterns for Solid Fuels.*

The Ladies' Program, arranged by Mrs. A. Wiley Sherwood, will feature a coffee hour on Oct. 25, followed by a tour of Rock Creek Park and luncheon at Normandy Farms. On Oct. 26, the ladies will tour Washington in the morning, with stops at Georgetown and Lincoln Memorial. A special luncheon and fashion show will be held at the Shoreham Hotel, and the highlight will be tea at the Pakistan Embassy.

Drilling Symposium Set October 11-13

The University of Minnesota will hold its Sixth Annual Drilling Symposium, Oct. 11-13, 1956, at the Center for Continuation Study, on the Minneapolis campus. Presented in cooperation with the University's School of Mines and Metallurgy, Institute of Technology, the symposium will concentrate on production drilling and blasting. The planning committee, representative of mining engineers and operators of the Lake Superior region, as well as of the educators, will deal with drilling and blasting practice in that area.

The tentative schedule includes the following topics: Principles of drilling hard rock; principles of blasting hard rock; drilling and blasting practice; and other hard rock properties. There will also be a Round Table and Open Discussion. On Sat. Oct. 13, the Minnesota—Northwestern football game will take place in the Memorial Stadium. Applications for registration should be made to: Director, Center for Continuation Study, University of Minnesota, Minneapolis 14. Fees for the symposium are $15.00. Those wishing to attend the football game should write directly to: Football Ticket Office, Cooke Hall, University of Minnesota. Mention registration for the symposium. Enclose $3.60 per ticket plus 25 cents postage.

PERSONALS

O. A. GLAESER

Oscar A. Glaeser was recently named a member of the Board of Governors, Salt Lake City Chamber of Commerce. Mr. Glaeser is vice president and general manager of Western operations, U. S. Smelting, Refining & Mining Co., Salt Lake City, and also vice president of U. S. Fuel Co.

Ora H. Rostad is geologist, The American Metal Co. Ltd., Denver. Mr. Rostad was formerly with U. S. Smelting, Refining & Mining Co., Salt Lake City.

J. B. HAFFNER

J. B. Haffner, president, International Oil & Metals Corp., has been awarded the honorary degree of doctor of science from the University of Idaho in recognition of his outstanding contribution to Idaho's mineral industry. Mr. Haffner studied mining engineering at the Royal Technical Institute in Stockholm, Sweden. He worked as an engineer and miner in England, France, Germany, and Russia, before coming to the U. S. in 1910. Prior to joining International Oil & Metals Corp., Mr. Haffner was president of The Bunker Hill Co., Kellogg, Idaho.

C. A. FITCH, JR.

Cecil A. Fitch, Jr., has been appointed president and general manager, Chief Consolidated Mining Co., Eureka, Utah, following the resignation of his father, **Cecil A. Fitch.** After graduating from Stanford University in 1939, Mr. Fitch, Jr., worked for United Air Lines until the latter part of 1940 when he joined the U. S. Army Air Force. In 1945 he was appointed assistant general manager of Chief Consolidated Mining Co., becoming vice president and general manager in 1950. Mr. Fitch, Sr., will remain with the company in a consulting capacity.

Paul M. Kavanagh is now chief geologist, Asbestos Corp. Ltd., Thetford Mines, Que. Mr. Kavanagh was with Cyprus Mines Corp., Skouriotissa, Cyprus.

Verne J. Tarne has joined Lucius Pitkin Inc., Moab, Utah. Mr. Tarne was with American Smelting & Refining Co. in Moab.

R. L. McCANN

R. L. McCann, president, The New Jersey Zinc Co., New York, recently received the sixteenth annual L-in-Life award from the Lehigh University Club of New York. After graduating from Lehigh University in 1917, Mr. McCann started work at the Franklin-Sterling mining operations of the New Jersey Zinc Co. He became president of the company in 1951.

Charles B. Reed is now engaged in general consulting work. His address is: P. O. Box 428, Austin, Texas. Mr. Reed was formerly chief engineer for Newmont Oil Co., and had been with the company since 1951. From 1936 to 1941 he was supervising seismologist for Shell Oil Co. During the next ten years he operated as an independent geologist in the mid-continent area.

Jack B. Ward has resigned as manager, Tsumeb Corp. Ltd., Tsumeb, S. W. Africa, and is now general manager, Heath Steele Mines Ltd., Newcastle, New Brunswick, Canada.

Richard E. Chamberlain, formerly with Andes Copper Mining Co., Chanaral, Chile, has returned to the U. S. and is at present employed by Reynolds Mining Corp. as a process engineer in the company's underground mine at Bauxite, Ark.

J. A. GUSTIN

J. A. Gustin has opened a consulting engineering office at 1206 Mulberry Road, Martinsville, Va. Mr. Gustin will serve the portland cement, industrial minerals, and allied fields in the U.S. and abroad. Mr. Gustin was formerly assistant manager and mill superintendent, Gouverneur Talc Co., Gouverneur, N. Y. Prior to that he was associated with Bessemer Limestone & Cement Co., Universal Atlas Cement Co., and the Coplay Cement Mfg. Co.

Niel Martin Fishback has been appointed sales manager, Mining and Contracting Div., Gardner-Denver Co. Mr. Fishback was district manager for the El Paso branch, and has been with the company since 1948.

Edward R. Weidlein, president of the Mellon Institute, Pittsburgh, has retired. Mr. Weidlein will remain on the board of trustees of the Institute and be available in an advisory capacity in the administration of the Institute's research programs.

William E. Wrather, former director of the U. S. Geological Survey, was presented with the Sidney Powers Medal by the American Assn. of Petroleum Geologists during its annual meeting in Chicago last April. This medal is the highest honor in the field of petroleum geology.

Thomas V. Barton, Jr., sales engineer, Dorr-Oliver Inc., Stamford, Conn., has joined Peterson Tractor & Equipment Co. in California.

Charles M. Mallette, mining engineer, Magma Copper Co., Superior, Ariz., is now geologist, exploration dept., Ideal Cement Co., Fort Collins, Colo.

Maurice A. E. Mawby has been awarded the Australasian Institute of Mining & Metallurgy Medal for 1955 in recognition of his contribution to exploration and to nonferrous metallurgy, and also of his continuous public service in many directions associated with mining and metallurgy. Mr. Mawby is director of exploration and research, Consolidated Zinc Pty. Ltd., Melbourne, Australia. The medal will be presented to Mr. Mawby during the annual conference of the Institute to be held in August at Broken Hill, New South Wales.

Joseph Conrad Twinem, civil and mining engineer and geologist, is now a consultant at 116 Charles Street, Easton, Pa. Mr. Twinem was with Warren Foundry & Pipe Corp., Phillipsburg, N. J.

John F. Emerson has been transferred by the Union Carbide Nuclear Co., a division of Union Carbide & Carbon Corp., from Bishop, Calif., to Grand Junction, Colo. Mr. Emerson, formerly mine superintendent of the Pine Creek tungsten mine, is now assistant manager of mines for the company's operations on the Colorado Plateau.

Fred W. Denton, Jr., is resident manager, Atlas Consolidated Mining & Development Corp., Cebu City, P. I. Mr. Denton was formerly mining engineer, Toledo Copper Mine, Cebu City.

Richard M. Belliveau is now consulting mining and civil engineer at 29 Orange Avenue, Long Beach 2, Calif. Mr. Belliveau was consulting engineer for American Smelting & Refining Co. in New York.

Charles E. Michener, chief exploration geologist, International Nickel Co. of Canada Ltd., Copper Cliff, Ont., is now vice president, Canadian Nickel Co., Toronto.

William H. Goodrich, general manager of the Chino Mines Div., Kennecott Copper Corp., Hurley and Santa Rita, N.M., has been awarded the honorary degree of doctor of laws by New Mexico A & M College. This was given as a tribute to Mr. Goodrich's services as an industrial leader in the state and for his service to colleges and public schools of New Mexico.

OBITUARIES

Charles Leighton Bradbury
An Appreciation by
Col. C. F. Williams

Charles L. Bradbury (Member 1920) died Apr. 3, 1956, in St. Petersburg, Fla. He was an owner of the San Pedro Mine Group, San Pedro, N. M., and long identified with mining in New Mexico. A past president (1942) of the New Mexico Mining Assn. and manager of mining enterprises in Mexico and Bolivia, he had many friends who respected him for his professional ability and integrity and enjoyed his personal charm and wit.

Mr. Bradbury served with distinction in France in World War I with the 29th Division and offered his services in the last war. He was a patriot, a respected citizen, and a Virginia gentlemen of the old school. Born in Petersburg, Va., Nov. 28, 1895, he joined the Richmond Blues and saw service on the Border in 1916 and, following World War I, attended the New Mexico School of Mines. He graduated in 1922 with the degree of Bachelor of Science and went to Leland Stanford University for a year's post graduate work. His first job took him to Mexico as engineer at the AS&R Charcas unit, S.L.P., and there he wrote his first professional paper, *Charcas, An Ancient District In San Luis Potosi, Mexico*. Returning to New Mexico to marry, he took his bride to the old gold-silver camp of Mogollon in that State, where he worked for a year as mine shift-boss, Mogollon Mines Co. But pull of far places was strong and he went back to Mexico to become superintendent of the Cabrestante Mines, Mazapil Copper Co., where the blood-stained floor in the quarters of his murdered predecessor evidenced the unsettled condition of Mexico in those years. From the Concepcion del Oro camp, he went to Cía. de Real del Monte as a Pachuca mine captain, and to Wadley, S.L.P., as superintendent and later manager for the Republican Mining & Metal Co.

Perhaps Mr. Bradbury's most noteworthy achievement followed his appointment in 1929 as manager of the Empresa Minera Huanuni and Empresa Minera Japo, both in the Oruro District of Bolivia. There he reorganized and rejuvenated the ailing tin properties of Simon Patino and put them on a profit making basis. On one occasion he flew to Paris in the Graf Zeppelin to confer with the mine owner, then the Bolivian Ambassador to France. Living at the altitude of 14,000 ft and operating mines up to 17,000 for seven years finally undermined the robust health of this rugged mining engineer and he returned to his beloved Virginia countryside to recuperate. In the East he met John J. Raskob and was persuaded to take over the management of the Raskob Mining Interests Inc., with properties in several Western states. From 1939 he concentrated operations at the San Pedro copper mine in New Mexico and, after several years of profitable operation, purchased this property from Mr. Raskob. Because of the fine record made at San Pedro, Mr. Raskob and his associate, Gen. Hugh Drum, appointed Mr. Bradbury vice president of a new mining and milling operation, Cía. Minera del Mexcala in Guerrero, Mexico, which position he held at the time of his death.

Mr. Bradbury is survived by his wife, Mrs. Marjorie Herrick Bradbury of Socorro, New Mexico, and his children, William, Emily, Marjorie, and Nancy.

Thomas Russell Drummond (Legion of Honor Member 1899) died Feb. 28, 1956, at his home in San Juan Capistrano, Calif. Mr. Drummond was a consulting engineer in Los Angeles, and manager of Zenda Gold Mining Co. from 1935 to 1950, when he retired. He was born in Colombo, Ceylon, in 1873, and educated at Herriott-Watt Technical College, Edinburgh, Scotland, and the School of Mines, London, England. After five years as an apprentice with the West End Engineering

Necrology

Date Elected	Name	Date of Death
1941	Ned W. Andrix	Jan. 8, 1956
1955	Norman Keith Glass	Apr. 3, 1956
1938	F. F. McLaughlin	Mar. 26, 1956
1919	William B. Plank	June 19, 1956
1943	Ronald C. Rowe	Mar. 27, 1956
1946	Marsh S. Watson, Jr.	May 27, 1956

Works, Edinburgh, Mr. Drummond was employed by Clarkson-Stanfield Concentrator Co., London, as an engineer and assayer. From 1897 to 1913, he worked for various companies in the U. S. and Canada. Mr. Drummond then went into private practice in the Philippines and in China. Mr. Drummond joined the Zenda Gold Mining Co. in 1934 as a mining engineer.

Pieter B. Vogelsang (Member 1955) died Feb. 22, 1956. Mr. Vogelsang was general mine superintendent, Cía. Minera de Bolivia, Oruro, Bolivia. He was born in Culemborg, Holland, in 1920. After graduating from the Technical University, Delft, Holland, in 1949, Mr. Vogelsang was mining engineer, Fabulosa Mines, La Paz, Bolivia. From 1951 to 1953 he was administrator, Empresa Minera Fenix, Oruro.

Victor Gárate Valdés (Member 1932) died Apr. 18, 1956. Mr. Gárate Valdés was director general, Negociación Minera Santa María de La Paz Anexas, México City. He was born in Salina, Oviedo, Spain, in 1903. After graduating from the Michigan College of Mining and Technology in 1926, Mr. Gárate Valdés worked for the Caracoles Tin Co., of La Paz, Bolivia. In 1930 he joined the Santa María de La Paz y Anexas, Matehuala, S.L.P., México, as mine superintendent.

William F. Mosier (Member 1955) died Dec. 26, 1955. Mr. Mosier was a student at the Missouri School of Mines, Rolla, Mo. He was born in 1936 in Washington, Ind.

Russell B. Paul (Member 1913), mining engineer and consultant, died of cancer on Mar. 5, 1956, at La Jolla, Calif. Mr. Paul was born in Gilpin County, Colo., in 1879. After graduating from the Colorado School of Mines in 1902 he gained experience in mining companies in Colorado, Nevada, and in Honduras. Mr. Paul joined the New Jersey Zinc Co. in 1925, and from 1928 to 1947 was resident mining engineer for the company in New York. He was a director of AIME from 1943 to 1949, and a past president of the Mining Club of New York.

Thor Warner (Member 1910) died Jan. 20, 1956. Mr. Warner was a consulting geologist in San Antonio, Texas. He was born near Gothenburg, Mich., in 1883. Mr. Warner's first job was with U. S. Steel Corp., Negaunee, Mich. From 1902 to 1912 he did exploration work in the Cobalt region of Canada. He then became a consulting petroleum geologist in San Antonio, Texas, and in Los Angeles. Mr. Warner was the discoverer of the Rio Puerco ruins in New Mexico in 1925.

David M. Wright, Sr., (Member 1948) died Mar. 11, 1956. Mr. Wright was general manager of the phosphate rock mines, Swift & Co., Bartow, Fla., from 1941 to 1952, when he retired. He was born in Escanaba, Mich., in 1887. After receiving his E.M. degree from the Michigan School of Mines in 1908, he worked for Swift & Co., in the Fuel & Mining Dept. During World War I he served as a captain in the Engineers. After the war he returned to Swift & Co. in Chicago. He was superintendent of the company's phosphate mine in Bartow from 1925 to 1941.

MEMBERSHIP

Proposed for Membership
Mining Branch, AIME

Total AIME membership on June 30, 1956 was 24,981; in addition 2,761 Student Associates were enrolled.

ADMISSIONS COMMITTEE

R. B. Caples, Chairman; F. A. Ayer, Vice-Chairman; A. C. Brinker, R. H. Dickson, C. R. Dodson, R. B. Fulton, T. D. Jones, F. W. Hanson, Sidney Rolle, F. T. Sisco, O. B. J. Fraser, F. W. McQuiston, Jr., A. R. Lytle, L. P. Warriner.

The Institute desires to extend its privileges to every person to whom it can be of service, but does not desire as members persons who are unqualified. Institute members are urged to review this list as soon as possible and immediately to inform the Secretary's office if names of people are found who are known to be unqualified for AIME membership.

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Coming Events

Aug. 19-24, Sixth International Symposium on Combustion, Yale University, New Haven, Conn.

Aug. 25, AIME, Adirondack Local Section, golf, Tupper Lake, N. Y.

Sept. 4-11, 20th International Geological Congress, Mexico City, Mexico.

Sept. 10, AIME, Mexico Local Section, dinner session in conjunction with 20th International Geological Congress, University Club, Mexico City, Mexico.

Sept. 15, AIME, Colorado MBD Subsection, joint meeting with **AIME Plateau Section,** Denver Hotel, Glenwood Springs, Colo.

Sept. 16-21, ASTM, annual meeting and exhibit, Pacific area, Hotel Statler, Los Angeles.

Sept. 22, AIME, Adirondack Local Section, visit to Appalachian Sulphides, South Strafford, Vt. Dinner, Lake Morey Inn, Fairlee, Vt.

Sept. 26-28, AIME Rocky Mountain Minerals Conference, Newhouse Hotel, Salt Lake City. Technical papers will represent all branches, including the Petroleum Div.

Oct. 1-4, American Mining Congress, Mining Show, Shrine Auditorium, Los Angeles.

Oct. 8-10, AIME, Institute of Metals Div., Carter Hotel, Cleveland.

Oct. 8-12, UPADI, fourth convention, Hotel del Prado, Mexico City, Mexico.

Oct. 11-13, University of Minnesota, Annual Drilling Symposium, Center for Continuation Study, University of Minnesota, Minneapolis.

Oct. 14-17, AIME, Petroleum Branch, Biltmore Hotel, Los Angeles.

Oct. 22-24, ASA, 38th annual meeting, Hotel Roosevelt, New York.

Oct. 25, 26, AIME-ASME Joint Solid Fuels Conference, *Future Role of Solid Fuels in an Expanding Economy,* Sheraton-Park Hotel, Washington, D. C.

Oct. 29-Nov. 1, Society of Exploration Geophysicists, 26th annual meeting, Hotel Roosevelt, New Orleans.

Oct. 31-Nov. 2, Gulf Coast Assn. of Geological Societies, sixth annual convention, Plaza Hotel, San Antonio, Texas.

Nov. 1-3, Geological Society of America, annual meeting, Minneapolis.

Nov. 1-3, New Mexico Mining Assn. and International Mining Days, Carlsbad, N. M.

Nov. 3, AIME, Adirondack Local Section, football game, Syracuse, N. Y.

Nov. 8-10, AIME, Northeastern Mining Branch Conference, Hotel Hershey, Hershey, Pa. Lehigh Valley Section is host.

Nov. 12-15, Amer. Petroleum Inst., annual meeting, Conrad Hilton Hotel, Chicago.

Dec. 5-7, AIME, Electric Furnace Steel Conference, Hotel Morrison, Chicago.

Feb. 7-9, Colorado Mining Assn., Denver.

Feb. 24-28, 1957, AIME Annual Meeting, Roosevelt and Jung Hotels, New Orleans.

Mar. 10-16, EJC Second Nuclear Engineering and Science Congress, Convention Hall, Philadelphia.

Apr. 1-4, Amer. Assn. of Petroleum Geologists, annual meeting, Kiel Auditorium, St. Louis.

Apr. 8-10, AIME National Open Hearth Steel and Blast Furnace, Coke Oven, and Raw Materials Conferences, William Penn Hotel, Pittsburgh.

Apr. 11-13, AIME, Pacific Northwest Regional Conference, Portland, Ore.

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